NASA SP-7011 (395)
December 1994

NAS 1.21:7011 (395)

0830-J-01

AEROSPACE MEDICINE AND BIOLOGY

A CONTINUING BIBLIOGRAPHY WITH INDEXES

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NASA SP-7011 (395)
December 1994

AEROSPACE MEDICINE AND BIOLOGY

A CONTINUING BIBLIOGRAPHY WITH INDEXES

National Aeronautics and Space Administration
Scientific and Technical Information Program
Washington, DC 1994

This publication was prepared by the NASA Center for AeroSpace Information,
800 Elkridge Landing Road, Linthicum Heights, MD 21090-2934, (301) 621-0390.

INTRODUCTION

This issue of *Aerospace Medicine and Biology* (NASA SP-7011) lists 82 reports, articles, and other documents recently announced in the NASA STI Database. The first issue of *Aerospace Medicine and Biology* was published in July 1964.

Accession numbers cited in this issue include:

Scientific and Technical Aerospace Reports (STAR) (N-10000 Series)	None in this issue
Open Literature (A-60000 Series)	A94-62105 — A94-62589

In its subject coverage, *Aerospace Medicine and Biology* concentrates on the biological, physiological, psychological, and environmental effects to which humans are subjected during and following simulated or actual flight in the Earth's atmosphere or in interplanetary space. References describing similar effects on biological organisms of lower order are also included. Such related topics as sanitary problems, pharmacology, toxicology, safety and survival, life support systems, exobiology, and personnel factors receive appropriate attention. Applied research receives the most emphasis, but references to fundamental studies and theoretical principles related to experimental development also qualify for inclusion.

Each entry in the publication consists of a standard bibliographic citation accompanied in most cases by an abstract. The listing of the entries is arranged by *STAR* categories 51 through 55, the Life Sciences division. The citations include the original accession numbers from the respective announcement journals.

Seven indexes—subject, personal author, corporate source, foreign technology, contract number, report number, and accession number—are included.

A cumulative index for 1994 will be published in early 1995.

Information on availability of documents listed, addresses of organizations, and CASI price schedules are located at the back of this issue.

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Includes physiological factors; biological effects of radiation; and effects of weightlessness on man and animals.

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Includes psychological factors; individual and group behavior; crew training and evaluation; and psychiatric research.

Category 54 **Man/System Technology and Life Support** N.A.
Includes human engineering; biotechnology; and space suits and protective clothing.

Category 55 **Space Biology** N.A.
Includes exobiology; planetary biology; and extraterrestrial life.

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TYPICAL REPORT CITATION AND ABSTRACT

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ACCESSION NUMBER → **N94-11045*#** Pennsylvania State Univ., Hershey. Coll. of ← **CORPORATE SOURCE**
Medicine.
TITLE → **EFFECTS OF CSF HORMONES AND IONIC COMPOSITION ON SALT/WATER METABOLISM Final Technical Report, 1 Mar. 1981 - 31 Dec. 1992**
AUTHOR → WALTER B. SEVERS 31 Dec. 1992 32 p ← **PUBLICATION DATE**
CONTRACT NUMBER → (Contract NCC2-127)
REPORT NUMBERS → (NASA-CR-193232; NAS 1.26:193232) Avail: CASI HC A03/MF ← **AVAILABILITY AND PRICE CODE**
A01

The consequences of headward fluid shifts during manned spaceflight was studied. Such shifts were recognized early by both U.S. and Soviet scientists because of signs and symptoms referable to the head. Some of these include disturbed vision, puffiness in the face and periorbital areas, headache, vestibular dysfunction, and distended jugular veins. We posited that the fluid shift had an immediate effect on the brain and a long-term action requiring a neural interpretation of the flight environment. This would re-adjust both efferent neural as well as hormonal mechanisms to sustain cardiovascular and fluid/electrolyte balance consonent with survival in microgravity. Work along these lines is summarized. A synopsis of some of the main research is presented. The following topics were studied: (1) angiotensin and vasopressin action in the central nervous system; (2) intracranial pressure control; (3) research on subcommissural organ; and (4) research on the eye.

Author (revised)

TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT

ACCESSION NUMBER → **A94-60203**
TITLE → **ESTIMATION OF THE LOW-EARTH-ORBIT DEBRIS POPULATION AND DISTRIBUTION**
AUTHORS → KYLE T. ALFRIEND General Research Corp., VA and ← **AUTHORS' AFFILIATION**
D. LAURIE LEWIS *Journal of Spacecraft and Rockets* (ISSN 0022- ← **JOURNAL TITLE**
4650) vol. 31, no. 1 January-February 1994 p. 48-53 refs ← **PUBLICATION DATE**
REPORT NUMBER → (BTN-94-EIX94311322893) Copyright

In this paper, an algorithm for estimating the low-Earth-orbit space object population and distribution from measurements taken by a vertical, staring narrow beam radar is developed and validated. The radar measures the altitude, inclination, and radar cross section of each object which passes through the beam. The effects of the assumptions made in developing the algorithm and measurement errors are discussed. An estimate of the operational time of the radar needed to achieve a specified accuracy in the space object population is also developed.

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AEROSPACE MEDICINE AND BIOLOGY

A Continuing Bibliography (Suppl. 395)

December 1994

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LIFE SCIENCES (GENERAL)

A94-62280

HYDROTHERMAL AND OCEANIC PH CONDITIONS OF POSSIBLE RELEVANCE TO THE ORIGIN OF LIFE

GORDON MACLEOD Univ. of Glasgow, Glasgow, Scotland, UK, CHRISTOPHER MCKEOWN Univ. of Glasgow, Glasgow, Scotland, UK, ALAN J. HALL Univ. of Glasgow, Glasgow, Scotland, UK, and MICHAEL J. RUSSELL Univ. of Glasgow, Glasgow, Scotland, UK *Origins of Life and Evolution of the Biosphere* (ISSN 0169-6149) vol. 24, no. 1 February 1994 p. 19-41
(Contract NERC-GR3/7779)
(HTN-94-00308) Copyright

Because of the continuous focusing of thermal and chemical energy, ancient submarine hot springs are contenders as sites for the origin of life. But it is generally assumed that these would be of the acid and high-temperature 'black smoker' variety (Corliss et al., 1981). In fact today the greater part of the ocean circulates through off-ridge springs where it issues after modification at temperatures of around 40 C or so but with the potential to reach 200 C. Such off-ridge or ridge-flank springs remind us that there are other candidate sites for the origin of life. Although there is no firm indication of the pH of these off-ridge springs we have argued that the solutions are likely to be alkaline rather than acid. We test the feasibility of this idea using EQ geochemical water-rock interaction modelling codes (Wolery 1983) and find that for a range of possible initial chemistries of Hadean seawater, the pH of issuing solutions at around 200 C is around one or more units alkaline. Such pH values hold for interaction with both basaltic and komatiitic crust. The robustness of this result suggests to us that alkaline submarine springs of moderate temperature, carrying many hundreds of ppm HS(-) to the ocean basins, are also serious contenders as sites for the origin of life, particularly as Hadean seawater was probably slightly acid, with a dissolved iron concentration approaching 100 ppm. On mixing of these solutions, supersaturation, especially of iron sulphide, would lead to the precipitation of colloidal gels. In our view iron sulphide was the likely substance of, or contributor to, the first vesicle membranes which led to life, as the supply of organic molecules would have been limited in the Hadean. Such a membrane would have had catalytic properties, expansivity, and would have maintained the natural chemiosmotic gradient, a consequence of the acid ocean and the alkaline interior to the vesicles. Author (revised by Herner)

A94-62281

FES/FES2: A REDOX SYSTEM FOR THE ORIGIN OF LIFE

MICHAEL KASCHKE Univ. of Glasgow, Glasgow, Scotland, UK, MICHAEL J. RUSSELL Univ. of Glasgow, Glasgow, Scotland, UK, and W. JOHN COLE Univ. of Glasgow, Glasgow, Scotland, UK *Origins of Life and Evolution of the Biosphere* (ISSN 0169-6149) vol. 24, no. 1 February 1994 p. 43-56
(Contract GR3(FE)7779)
(HTN-94-00314) Copyright

The FeS/FS2 redox system, whose importance is stressed in recent theories on the origin of life, has been tested experimentally. In this paper it is demonstrated by thermodynamical calculations as well as by experiments, that cyclohexanone, which served as model compound, can be reduced by the aforementioned redox system. Reactions were carried out in methanol and dimethylformamide (DMF) at 25 C and at 100 C. Besides products that were synthesized in both solvents, like cyclohexanethiol and dicyclohexyldisulphide, special compounds were obtained in methanol and in DMF, because of the environment of the respective solvent in the reaction. Yields of reduced compounds were lower in methanol owing to a compound that hindered the reduction (cyclohexylketal). With increasing temperature and duration the amount of reduced compounds increased. Further experiments have shown that 1, 1-cyclohexanedithiol is likely to be a necessary intermediate for the reduced products. The experiments give evidence to the 'pyrite hypothesis', which postulates that the FeS/FS2 redox system was of importance for the origin of life. Author (revised by Herner)

A94-62282

DID REFLEXIVE CATALYSTS DRIVE CHEMICAL EVOLUTION?

GORDON ALLEN National Inst. of Mental Health, Bethesda, MD, US *Origins of Life and Evolution of the Biosphere* (ISSN 0169-6149) vol. 24, no. 1 February 1994 p. 57-61
(HTN-94-00315) Copyright

High-energy starting materials and energy sources on the primitive earth would have generated abundant and varied organic molecules of small or medium size. It is questionable, however, whether ordinary chemical evolution could have produced information-carrying polymers. The end point might have been a fixed steady state if some form of autocatalysis had not intervened. Autocatalytic synthesis is possible for small molecules as illustrated by the formose reaction, in which glycolaldehyde condenses with formaldehyde to form sugars, and resulting tetroses may cleave into two molecules of glycolaldehyde. This and other 'reflexive catalysts', some functioning in molecular aggregates, may have energized chemical evolution and carried it to a level at which ribonucleic acid (RNA) or an RNA analog could replicate itself. Author (revised by Herner)

A94-62285

ENANTIOSELECTIVE AUTOCATALYSIS. SPONTANEOUS RESOLUTION AND THE PREBIOTIC GENERATION OF CHIRALITY

WILLIAM A. BONNER Stanford Univ., Stanford, CA, US *Origins of Life and Evolution of the Biosphere* (ISSN 0169-6149) vol. 24, no. 1 February 1994 p. 63-78
(HTN-94-00319) Copyright

Theoretical and experimental models for autocatalytic systems leading to the prebiotic origin of chirality via the spontaneous symmetry breaking (resolution) of racemic substrates are reviewed. Of the experimental models so far studied, only 2nd order assymetric transformations during crystallization of optically labile enantiometers, leading to their Spontaneous Resolution Under Racemizing Conditions (SRURC) have been successful. Our objective was to investigate in further detail the most promising of these systems from the point of view of its overall efficiency and its potential viability as a mechanism for the spontaneous generation of molecular chirality on the prebiotic Earth. To this end the 1,4-benzodiazepinooxazole derivative XI, having a single asymmetric carbon atom, has been synthesized. We here confirm a report in the literature that (+/-)-XI undergoes SRURC in methanol, both on crystallization and as a slurry. The 'total spontaneous resolution' of (+/-)-XI has been achieved in a yield of 99%, of which 80% had an optical purity of ca. 93%. Arguments are presented that SRURC of racemic substrates, while thus demonstrably effective in laboratory experiments, was probably not of major importance for the origin or amplification of molecular chirality on the primitive earth. Author (revised by Herner)

A94-62471

INFLUENCE OF A LONG DURATION EXPOSURE, 69 MONTHS, TO THE SPACE FLIGHT FACTORS IN ARTEMIA CYSTS, TOBACCO, AND RICE SEEDS

H. PLANEL Laboratoire de Radiobiologie et Biologie Spatiale, Toulouse, France, Y. GAUBIN Laboratoire de Radiobiologie at Biologie Spatiale, Toulouse, France, B. PIANEZZI Laboratoire de Radiobiologie et Biologie Spatiale, Toulouse, France, M. DELPOUX Universite de Toulouse, Toulouse, France, J. BAYONOVE Universite des Sciences et Techniques du Languedoc, Montpellier, France, J. C. BES Laboratoire de Radiobiologie et Biologie Spatiale, Toulouse, France, C. HEILMANN Centre de Recherches Nucleaires de Strasbourg, Strasbourg, France, and G. GASSET Laboratoire de Radiobiologie et Biologie Spatiale, Toulouse, France vol. 14, no. 10 October 1994 p. 21-32 Life Sciences and Space Research 25 (2) Radiation Biology: Topical Meeting of the COSPAR Interdisciplinary Scientific Commission F of the COSPAR 29th Plenary Meeting, Washington, DC, Aug. 28-Sep. 5, 1992 Research sponsored by the Centre National d'Etudes Spatiales

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Three French laboratories have participated in the Free Flyer Biostack experiment. Artemia cysts, tobacco seeds and rice caryopsis and embryos were used. Biological objects in monolayers were dead. In opposite, a large fraction of samples used in bulk survived. A stimulatory effect occurred in the first steps of development in Artemia cysts. In fact, the larval survival was unchanged or slightly reduced. In tobacco a drastic decrease in germination and survival rate was observed. Space flight did not induce genetic changes. In rice, results depend on the variety which was investigated; the growth rate stimulation in flight samples is discussed with respect to controls.

Author (revised by Herner)

A94-62472 National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.

MUTATIONAL EFFECTS OF SPACE FLIGHT ON ZEA MAYS SEEDS

M. MEI South China Agricultural Univ., Guangzhou, CN, Y. QIU South China Agricultural Univ., Guangzhou, CN, Y. HE South China Agricultural Univ., Guangzhou, CN, H. BUCKER Institute of Aerospace Medicine, Cologne, DE, and C. H. YANG NASA, Johnson Space Center, Houston, TX, US vol. 14, no. 10 October 1994 p. 33-39 Life Sciences and Space Research 25 (2) Radiation Biology: Topical Meeting of the COSPAR Interdisciplinary Scientific Commission F of the COSPAR 29th Plenary Meeting, Washington, DC, Aug. 28-Sep. 5, 1992

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The growth and development of more than 500 Zea mays seeds flown on Long Duration Exposure Facility (LDEF) were studied. Somatic mutations, including white-yellow stripes on leaves, dwarfing, change of leaf sheath color or seedling color were observed in plants developed from these seeds. When the frequency of white-yellow formation was used as the endpoint and compared with data from ground based studies, the dose to which maize seeds might be exposed during the flight was estimated to be equivalent to 635 cGy of gamma rays. Seeds from one particular holder gave a high mutation frequency and a wide mutation spectrum. White-yellow stripes on leaves were also found in some of the inbred progenies from plants displayed somatic mutation. Electron microscopy studies showed that the damage of chloroplast development in the white-yellow stripe on leaves was similar between seeds flown on LDEF and that irradiated by accelerated heavy ions on ground. Author (revised by Herner)

A94-62473

LONG-TERM SURVIVAL OF BACTERIAL SPORES IN SPACE

G. HORNECK Institute of Aerospace Medicine, Koln, DE, H. BUCKER Institute of Aerospace Medicine, Koln, DE, and G. REITZ Institute of Aerospace Medicine, Koln, DE vol. 14, no. 10 October 1994 p. 41-45 Life Sciences and Space Research 25 (2) Radiation Biology: Topical Meeting of the COSPAR Interdisciplinary Scientific Commission F of the COSPAR 29th Plenary Meeting, Washington, DC, Aug. 28-Sep. 5, 1992 Research sponsored by the NASA LDEF Project Team

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On board of the NASA Long Duration Exposure Facility (LDEF), spores of Bacillus subtilis in monolayers (10(exp 6)/sample) or multilayers (10(exp 8)/sample) were exposed to the space environment for nearly six years and their survival was analyzed after retrieval. The response to space parameters, such as vacuum (10(exp -6) Pa), solar electromagnetic radiation up to the highly energetic vacuum-ultraviolet range 10(exp 9) J/sq m) and/or cosmic radiation (4.8 Gy), was studied and compared to the results of a simultaneously running ground control experiment. If shielded against solar ultraviolet (UV)-radiation, up to 80% of spores in multilayers survive in space. Solar UV-radiation, being the most deleterious parameter of space, reduces survival by 4 orders of magnitude or more. However, up to 10(exp 4) viable spores were still recovered, even in completely unprotected samples. Substances, such as glucose or buffer salts serve as chemical protectants. With this 6 year study in space, experimental data are provided to the discus-sion on the likelihood of 'Panspermia'. Author (revised by Herner)

A94-62474

FIRST RADIOBIOLOGICAL RESULTS OF LDEF-1 EXPERIMENT A0015 WITH ARABIDOPSIS SEED EMBRYOS AND SORDARIA FUNGUS SPORES

M. W. ZIMMERMAN Johann Wolfgang Goethe Univ., Frankfurt/Main, DE, K. E. GARTENBACH Johann Wolfgang Goethe Univ., Frankfurt/Main, DE, and A. R. KRANZ Johann Wolfgang Goethe Univ., Frankfurt/Main, DE vol. 14, no. 10 October 1994 p. 47-51 Life Sciences and Space Research 25 (2) Radiation Biology: Topical Meeting of the COSPAR Interdisciplinary Scientific Commission F of the COSPAR 29th Plenary Meeting, Washington, DC, Aug. 28-Sep. 5, 1992

(Contract AZ 01 QV 85650)

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This article highlights the first results of investigations on the general vitality and damage endpoints caused by cosmic ionizing radiation in dry, dormant plant seeds of the crucifer plant Arabidopsis thaliana (L.) Heynh. and the ascomycete Sordaria fimicola after 69 month stay in space. Wild-type and mutant gene marker lines were included in Free Lyer Biostack containers and exposed on earth and side tray of the Long Duration Exposure Facility (LDEF)-1 satellite. The damage in biological endpoints observed in the seeds increased in the side tray sample compared to the earth tray sample. For the ascospores we found different effects depending on the biological end points investigated for both expositions. Author (revised by Herner)

A94-62475

INVESTIGATION ON RICE EMBRYOS AND SEEDS AFTER THE LDEF FLIGHT: ELECTRONIC SPIN RESONANCE IDENTIFICATION

J. F. BAYONOVE Montpellier Univ. 2, Montpellier, France, J. J. RAFFI Centre de Cadarache, St. Paul lez Dur, France, and J-P. L. AGNEL Centre de Cadarache, St. Paul lez Dur, France vol. 14, no. 10 October 1994 p. 53-57 Life Sciences and Space Research 25 (2) Radiation Biology: Topical Meeting of the COSPAR Interdisciplinary Scientific Commission F of the COSPAR 29th Plenary Meeting, Washington, DC, Aug. 28-Sep. 5, 1992

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Rice caryopsis of Cigalon variety with short grain of the Long Duration Exposure Facility (LDEF) mission can develop and grow as well as those of the laboratory control. Rice caryopsis of Delta variety with long grain did not develop while a small number of excised embryos can develop and grow as well as the control group. A preliminary study of the Electron Spin Resonance (ESR) spectra of Rice embryos and seeds recorded several month after the flight on flight samples and on control ones has been carried out. All these samples had the same storage time. During storage the radical concentration which usually decreases, now depends on irradiation doses and on whether or not they were delivered in presence of oxygen. The signal variations are smaller than those usually observed in the different parts of the starch. An estimation of a 'gamma-equivalent-dose' can be reached.

Author (revised by Herner)

A94-62477* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.

MEASUREMENTS OF TRAPPED PROTONS AND COSMIC RAYS FROM RECENT SHUTTLE FLIGHTS

G. D. BADHWAR NASA, Johnson Space Center, Houston, TX, US, A. KONRADI NASA, Johnson Space Center, Houston, TX, US, L. A. BRABY Battelle Northwest Laboratory, Richland, WA, US, W. ATWELL Rockwell International Inc., Houston, TX, US, and F. A. CUCINOTTA NASA, Langley Research Center, Hampton, VA, US vol. 14, no. 10 October 1994 p. 67-72 Life Sciences and Space Research 25 (2) Radiation Biology: Topical Meeting of the COSPAR Interdisciplinary Scientific Commission F of the COSPAR 29th Plenary Meeting, Washington, DC, Aug. 28-Sep. 5, 1992

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We have flown two new charged particle detectors in five recent Shuttle flights. In this paper we report on the dose rate, equivalent dose rate, and radiation quality factor for trapped protons and cosmic radiation separately. A comparison of the integral Linear Energy Transfer (LET) spectra with recent transport code calculations show significant disagreement. Using the calculated dose rate from the omnidirectional AP8MAX model with IGRF reference magnetic field epoch 1970, and observed dose rate as a function of (averaged over all geographic latitude) and longitude, we have determined the westward drift of the South Atlantic anomaly. We have also studied the east-west effect, and observed a 'second' radiation belt. A comparison of the galactic cosmic radiation lineal energy transfer spectra with model calculations shows disagreement comparable to those of the trapped protons. Author (Herner)

A94-62480* National Aeronautics and Space Administration. Pasadena Office, CA.

RADIATION EFFECTS IN NEMATODES: RESULTS FROM IML-1 EXPERIMENTS

G. A. NELSON Jet Propulsion Laboratory, Pasadena, CA, US, W. W. SCHUBERT Jet Propulsion Laboratory, Pasadena, CA, US, G. A. KAZARIANS Jet Propulsion Laboratory, Pasadena, CA, US, G. F. RICHARDS Jet Propulsion Laboratory, Pasadena, CA, US, E. V. BENTON Univ. of San Francisco, San Francisco, CA, US, E. R. BENTON Univ. of San Francisco, San Francisco, CA, US, and R. HENKE Univ. of San Francisco, San Francisco, CA, US vol. 14, no. 10 October 1994 p. 87-91 Life Sciences and Space Research 25 (2) Radiation Biology: Topical Meeting of the COSPAR Interdisciplinary Scientific Commission F of the COSPAR 29th Plenary Meeting, Washington, DC, Aug. 28-Sep. 5, 1992

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The nematode Caenorhabditis elegans was exposed to natural space radiation using the ESA biorack facility aboard Spacelab on International Microgravity Laboratory 1, STS-42. For the major experimental objective dormant animals were suspended in buffer or on agar or immobilized next to CR-39 plastic nuclear track detectors to correlate fluence of HZE particles with genetic events. This configuration was used to isolate mutations in a set of 350 essential genes as well as in the unc-22 structural gene. From flight samples 13 mutants in the unc-22 gene were isolated along with 53 lethal mutations from autosomal regions balanced by a translocation eT1(III;V). Preliminary analysis suggests that mutants from worms correlated with specific cosmic ray tracks may have a higher proportion of rearrangements than those isolated from tube cultures on a randomly sampled basis. Flight sample mutation rate was approximately 8-fold higher than ground controls which exhibitedlaboratory spontaneous frequencies. Author (Herner)

A94-62481

PARTICLE TRAJECTORIES IN SEEDS OF LACTUCA SATIVA AND CHROMOSOME ABERRATIONS AFTER EXPOSURE TO COSMIC HEAVY IONS ON COSMOS BIOSATELLITES 8 AND 9

R. FACIUS Institute for Aerospace Medicine, Koln, Germany, K. SCHERER Institute for Aerospace Medicine, Koln, Germany, G. REITZ Institute for Aerospace Medicine, Koln, Germany, H. BUCKER Institute for Aerospace Medicine, Koln, Germany, L. V. NEVZGODINA Institute of Biomedical Problems, Moscow, RS, and E. N. MAXIMOVA Institute of Biomedical Problems, Moscow, RS vol. 14, no. 10 October 1994 p. 93-103 Life Sciences and Space Research 25 (2) Radiation Biology: Topical Meeting of the COSPAR Interdisciplinary Scientific Commission F of the COSPAR 29th Plenary Meeting, Washington, DC, Aug. 28-Sep. 5, 1992

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The potentially specific importance of the heavy ions of the galactic cosmic radiation for radiation protection in manned spaceflight continues to stimulate in situ, i.e., spaceflight experiments to investigate their radiobiological properties. Chromosome aberrations as an expression of a direct assault on the genome are of particular interest in view of cancerogenesis being the primary radiation risk for man in space. In such investigations the establishment of the geometrical correlation between heavy ions' trajectories and the location of radiation sensitive biological substructures is an essential task. The overall qualitative and quantitative precision achieved for the identification of particle trajectories in the order of approximately equal to 10 micrometers as well as the contributing sources of uncertainties are discussed. We describe how this was achieved for seeds of Lactuca sativa as biological test organisms, whose location and orientation had to be derived from contact photographies displaying their outlines and those of the holder plates only. The incidence of chromosome aberrations in cells exposed during the COSMOS 1887 (Biosatellite 8) and the COSMOS 2044 (Biosatellite 9) mission was determined for seeds hit by cosmic heavy ions. In those seeds the incidence of both single and multiple chromosome aberrations was enhanced. The results of the Biosatellite 9 experiment, however, are confounded by spaceflight effects unrelated to the passage of heavy ions.

Author (revised by Herner)

A94-62482

COSMIC IONIZING RADIATION EFFECTS IN PLANT SEEDS AFTER SHORT AND LONG DURATION EXPOSURE FLIGHTS

K. E. GARTENBACH Johann Wolfgang Goethe Univ., Frankfurt/Main, DE, M. PICKERT Johann Wolfgang Goethe Univ., Frankfurt/Main, DE, M. W. ZIMMERMANN Johann Wolfgang Goethe Univ., Frankfurt/Main, DE, and A. R. KRANZ Johann Wolfgang Goethe Univ., Frankfurt/Main, DE vol. 14, no. 10 October 1994 p. 105-108 Life Sciences and Space Research 25 (2) Radiation Biology: Topical Meeting of the COSPAR Interdisciplinary Scientific Commission F of the COSPAR 29th Plenary Meeting, Washington, DC, Aug. 28-Sep. 5, 1992

(Contract FKZ 10 QV 85650)

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Recently, comparison of biophysical data obtained from orbital flights of short and long duration led to results which will be significant for long and/or repeated stay of man in space. Under orbital conditions biological stress is induced in dry seeds of Arabidopsis thaliana by cosmic radiation especially its high energetic, densely ionizing component, the heavy ions (HZE). For comparison of radiation impact during different space flights a biological attempt at estimating the impact of single particles with high mass and energy (HZE-particles) on seeds was developed. Subdivision into Linear Energy Transfer (LET)-groups showed a remarkable contribution of an intermediate group (LET = 35 to 100 keV/micrometer) due to medium heavy ions (Z = 6 to 10). Efficiency factors for radiation damage experimentally determined and assigned to different LET-classes were compared to radiation quality factors discussed in literature. Author (revised by Herner)

A94-62483

EFFECTS OF LONG DURATION SPACE FLIGHT ON RICE SEED (OR EMBRYO) RADIATION SENSITIVITY AND ELEMENT MICROLOCALIZATIONS

J. F. BAYONOVE Montpellier-2 Univ, Montpellier, FR, A. MIR Montpellier-2 Univ., Montpellier, FR, and M. BURG Montpellier-2 Univ., Montpellier, FR vol. 14, no. 10 October 1994 p. 109-113 Life Sciences and Space Research 25 (2) Radiation Biology: Topical Meeting of the COSPAR Interdisciplinary Scientific Commission F of the COSPAR 29th Plenary Meeting, Washington, DC, Aug. 28-Sep. 5, 1992

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In long duration space experiments Rice caryopses and embryos, which are able to remain alive 10 years (or more) and tolerate extreme physical conditions (temperature, few water content) during irradiation and post-irradiation storage, were used (8, 40, 201 and 457 days on board of Salyut 7, 2107 days on Long Duration Exposure Facility (LDEF). In certain experiments (Salyut 7), samples were irradiated either before or after the flight. Effects of the flight and radiosensitivity were observed in Rice seedlings cultivated in in vitro conditions. Statistical results indicate an increase in radiosensitivity when irradiations occur before the flight. Microanalyses were made in different parts of one caryopses and of one embryo, and the results compared with those of control samples. With caryopses and embryos of the same Rice varieties, but from LDEF, we made the same kinds of experiments to compare results. Author (revised by Herner)

A94-62486

REPAIR OF RADIATION INDUCED GENETIC DAMAGE UNDER MICROGRAVITY

H.-D. PROSS Strahlenzentrum der Justus-Liebig-UnivGiessen, Giessen, Germany, M. KOST Strahlenzentrum der Justus-Liebig-UnivGiessen, Giessen, Germany, and J. KIEFER Strahlenzentrum der Justus-Liebig-UnivGiessen, Giessen, Germany vol. 14, no. 10 October 1994 p. 125-130 Life Sciences and Space Research 25 (2) Radiation Biology: Topical Meeting of the COSPAR Interdisciplinary Scientific Commission F of the COSPAR 29th Plenary Meeting, Washington, DC, Aug. 28-Sep. 5, 1992 Research sponsored by the Deutsche Agentur fur Raumfahrtangelegentheiten (DARA)

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The influence of microgravity on the repair of radiation induced genetic damage in a temperature-conditional repair mutant of the yeast Saccharomyces cerevisiae (rad 54-3) was investigated onboard the International Microgravity Laboratory (IML)-1 mission (January 22th-30th 1992, STS-42). Cells were irradiated before the flight, incubated under microgravity at the permissive (22 C) and restrictive (36 C) temperature and afterwards tested for survival. The results suggest that repair may be reduced under microgravity. Author (revised byHerner)

A94-62487* National Aeronautics and Space Administration, Washington, DC.

THE NASA SPACE RADIATION HEALTH PROGRAM

W. SCHIMMERLING NASA, Headquarters, Washington DC, US and F. M. SULZMAN NASA, Headquarters, Washington DC, US vol. 14, no. 10 October 1994 p. 133-137 Life Sciences and Space Research 25 (2) Radiation Biology: Topical Meeting of the COSPAR Interdisciplinary Scientific Commission F of the COSPAR 29th Plenary Meeting, Washington, DC, Aug. 28-Sep. 5, 1992

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The NASA Space Radiation Health Program is a part of the Life Sciences Division in the Office of Space Science and Applications (OSSA). The goal of the Space Radiation Health Program is development of scientific bases for assuring adequate radiation protection in space. A proposed research program will determine long-term health risks from exposure to cosmic rays and other radiation. Ground-based animal models will be used to predict risk of exposures at varying levels from various sources and the safe levels for manned space flight. Author (Herner)

A94-62488

SPACE RADIOBIOLOGY PROGRAM IN RUSSIA

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The space radiobiology program in Russia is aimed at obtaining fundamental data for developing radiation safety criteria. These criteria are necessary for long-term space missions. This program includes: substantiation of radiation hazard estimation principles based on the radiation risk conception, investigation of the radiation affection regularities under the combined influence of the spaceflight factors, experimental investigation of the HZE-particle delayed effects and acute somatic effects induced by protons and electrons, individual radiosensitivity investigation, mathematic modeling of radiobiological effects, radiobiological basis of control and forecast of radiation influence in space, development of methods and means of an organism's radioresistance increase. Author (Herner)

A94-62489

TRACK STRUCTURE AND DNA DAMAGE

M. KRAMER Gesellschaft fur Schwerionenforschung, Darmstadt, DE and G. KRAFT Gesellschaft fur Schwerionenforschung, Darmstadt, DE vol. 14, no. 10 October 1994 p. 151-159 Life Sciences and Space Research 25 (2) Radiation Biology: Topical Meeting of the COSPAR Interdisciplinary Scientific Commission F of the COSPAR 29th Plenary Meeting, Washington, DC, Aug. 28-Sep. 5, 1992 Research sponsored by DARA, Bonn

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Heavy particles like protons or heavier ions are different in their biological efficiency when compared to sparsely ionizing radiation. These differences have been attributed to the different pattern of energy deposition in the track of the particles. In radiobiological models two different approaches are used for the characterization of the radiation quality: the continuous dose distribution of the various track structure models and the separation in small compartments inside the track which are used in microdosimetry. In a recent Monte Carlo calculation using the binary encounter approximation as input for the electron emission process, the radial distribution of the dose is calculated for heavy ions. The result of this calculation is compared to other models and used for a qualitative interpretation of the induction of DNA damage by particles. Author (Herner)

A94-62490

MONTE CARLO TRACK STRUCTURE STUDIES OF ENERGY DEPOSITION AND CALCULATION OF INITIAL DSB AND RBE

H. NIKJOO MRC Radiobiology Unit, Chilton, Didcot, UK, D. E. CHARLTON Concordia Univ., Montreal, Quebec, CA, and D. T. GOODHEAD MRC Radiobiology Unit, Chilton, Didcot, UK vol. 14, no. 10 October 1994 p. 161-180 Life Sciences and Space Research 25 (2) Radiation Biology: Topical Meeting of the COSPAR Interdisciplinary Scientific Commission F of the COSPAR 29th Plenary Meeting, Washington, DC, Aug. 28-Sep. 5, 1992 Research sponsored by the Rutherford Appleton Laboratories

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Estimation of exposure due to environmental and other sources of radiations of high-Linear Energy Transfer (LET) and low-LET is of interest in radiobiology and radiation protection for risk assessment. To account for the differences in effectiveness of different types of radiations various parameters have been used. However, the relative inadequacy of the commonly used parameters, including dose, fluence, linear energy transfer, lineal energy, specific energy and quality factor, has been made manifest by the biological importance of the microscopic track structure and primary modes of interaction. Monte Carlo track structure simulations have been used to calculate the frequency of energy deposition by radiations of high- and low-LET in target sizes similar to DNA and higher order genomic structure. Tracks of monenergetic heavy ions and electrons were constructed by following the molecular interaction-by-interaction histories of the particles down to 10 eV. Subsequently, geometrical models of these assumed biological targets were randomly exposed to the radiation tracks and the frequency of energy depositions obtained were normalized to unit dose in unit density liquid water 10(exp 3) kg m(exp -3). From these data and a more sophisticated model of the DNA, absolute yields of both single- and double-strand breaks expressed in number of breaks per dalton per Gray were obtained and compared with the measured yields. The Relative Biological Effectiveness (RBE) for energy depositions in cylindrical targets has been calculated using 100 keV electrons as the reference radiation assuming the electron track-ends contribution is similar to that in 250 kV X-ray or (60) Co gamma-ray irradiations.

Author (revised by Herner)

A94-62491

ENERGY AND CHARGE LOCALIZATION IN IRRADIATED DNA

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The relation between the site of energy deposition and the site of its biological action is an important question in radiobiology. Even at 77 K, evidence is clear that these two sites must be separated since energy deposition is random but specific products are formed. Several processes that may contribute to this separation are: 1) hole migration and stabilization through deprotonation to give neutral oxidation product radicals; 2) electron trapping and transfer to form specific radical anions, possibly followed by protonation to give neutral reduction product radicals; and 3) recombination of spatially separated charges or radicals. These microscopic processes will be reviewed critically in an analysis using electron paramagnetic resonance spectroscopy (EPR) evidence for and against long-range transfer of energy and/or charge in frozen hydrated DNA. Author (revised by Herner)

A94-62492

HEAVY ION INDUCED DNA DOUBLE STRAND BREAKS IN CELLS OF E. COLI

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Vegetative cells of E. coli differing in their radiosensitivity have been used in heavy ion irradiation experiment. Besides inactivation measurements also the induction of DNA Double Strand Breaks (DSB) have been measured using the method of pulse-field gel electrophoresis. This method allows to separate linear DNA with length up to 8 Mio base pairs. After irradiation with heavy ions we find a higher amount of low molecular weight fragments when compared to sparsely ionizing radiation. This agrees with the idea that heavy ions as a structured radiation have a high probability to induce more than one strand break in a DNA molecule if the particle hits the DNA. The amount of intact DNA remaining in the agarose plugs decreases exponentially for increasing radiation doses or particle fluences. From these curves cross sections for the induction of DSB after heavy ion irradiation have been determined. These results will be discussed in comparison to the results for cell survival. Author (Herner)

A94-62493

DOUBLE STRAND BREAKS IN THE DNA OF BACILLUS SUBTILIS CELLS IRRADIATED BY HEAVY IONS

U. MICKE Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Koln, Germany, G. HORNECK Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Koln, Germany, and S. KOZUBEK Institute of Biophysics, Brno, Czech Republic vol. 14, no. 10 October 1994 p. 207-211 Life Sciences and Space Research 25 (2) Radiation Biology: Topical Meeting of the COSPAR Interdisciplinary Scientific Commission F of the COSPAR 29th Plenary Meeting, Washington, DC, Aug. 28-Sep. 5, 1992

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Cells of Bacillus subtilis strain TKJ 8431 in stationary phase were irradiated with X-rays (150 kV at DLR) or heavy ions (Ne, Ar, Pb with residual energies between 3 and 15 MeV/u at GSI). The action cross section for the formation of double strand breaks in the DNA of the irradiated cells follows a similar dependence on mass and energy of the ions as has been found for various biological endpoints, e.g. inactivation, mutagenesis and repair efficacy. Author (Herner)

A94-62494

EFFECTS OF HEAVY IONS ON INACTIVATION AND DNA DOUBLE STRAND BREAKS IN DEINOCOCCUS RADIODURANS R1

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Inactivation and Double Strand Break (DSB) induction after heavy ion irradiation were studied in stationary phase cells of the highly radiation resistant bacterium Deinococcus radiodurans R1. There is evidence that the radiation sensitivity of this bacterium is nearly independent on energy in the range of up to 15 MeV/u for lighter ions (Ar). The responses to dsb induction for charged particles show direct relationship between increasing radiation dose and residual intac DNA. Author (Herner)

A94-62495* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.

EFFECTS OF AR-40 AND FE-56 IONS ON RETINAL PHOTORECEPTOR CELLS OF THE RABBIT: IMPLICATIONS FOR MANNED MISSIONS TO MARS

G. R. WILLIAMS Colorado State Univ., Ft. Collins, CO, US and J. T. LETT Colorado State Univ., Ft. Collins, CO, US vol. 14, no. 10 October 1994 p. 217-220 Life Sciences and Space Research 25 (2) Radiation Biology: Topical Meeting of the COSPAR Interdisciplinary Scientific Commission F of the COSPAR 29th Plenary Meeting, Washington, DC, Aug. 28-Sep. 5, 1992 Research sponsored by the Department of Energy

(Contract NAG9-10)

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Losses of photoreceptor cells (rods) from the retinas of New Zealand white (NZW) rabbits were detectable within 2 years after localized acute irradiation of optic and proximal tissues with greater than or equal to 7 Gy of 530 MeV u(exp -1) Ar-40 ions or greater than or equal to 2 Gy of 465 MeV u(exp -1) Fe-56 ions in the Bragg plateau region of energy deposition. Those limits were determined only from an analysis of variance of dose groups because the shapes of the dose response curves at early post-irradiation times are not known, a concern being addressed by experiments in progress. Losses of photoreceptor cells for the period 0.5-2.5 years post-irradiation, determined by provisional linear regression analysis, were approxiamtely 1.7% Gy(exp -1) and 2.5% Gy(exp.-1) for Ar-40 and Fe-56 ions, respectively. Author (revised by Herner)

A94-62496

THE ROLE OF HYDRATION AND RADIATION QUALITY IN THE INDUCTION OF DNA DAMAGE-CHEMICAL ASPECTS

P. O'NEILL MRC Radiobiology Unit, Chilton, Didcot, UK vol. 14, no. 10 October 1994 p. 221-234 Life Sciences and Space Research 25 (2) Radiation Biology: Topical Meeting of the COSPAR Interdisciplinary Scientific Commission F of the COSPAR 29th Plenary Meeting, Washington, DC, Aug. 28-Sep. 5, 1992
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The mutagenic and lethal effects of ionizing radiation are thought to result from chemical modifications induced within DNA. This DNA damage is significantly influenced by the chemical environment and the radiation quality Linear Energy Transfer (LET). Water closely associated with the DNA and its immediate environment is involved in the early chemical pathways which lead to the induction of DNA damage and is reflected in the cellular radiosensitivity. For instance, hydration of DNA influences hole migration leading to its localization at guanine. Changes in the radiation quality are discussed in terms of the complexity of the radical clusters produced. It is inferred that at higher LET, the influence of the chemical environment (O2 etc) decreases with respect to DNA damage and cellular radiosensitivity. It is therefore important to include these effects of environment of the DNA upon the early chemical pathways in models of radiation action. Author (revised by Herner)

A94-62497

REPAIR OF DNA DOUBLE-STRAND BREAKS AND ITS EFFECT ON RBE

D. FRANKENBERG Gottingen Universitat, Gottingen, DE vol. 14, no. 10 October 1994 p. 235-248 Life Sciences and Space Research 25 (2) Radiation Biology: Topical Meeting of the COSPAR Interdisciplinary Scientific Commission F of the COSPAR 29th Plenary Meeting, Washington, DC, Aug. 28-Sep. 5, 1992
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DNA double-strand breaks (DSB) are induced linearly with absorbed dose both for sparsely and densely ionizing radiations. By enzymatic repair on the linear relationship between the number of DSB and absorbed dose is converted into a nonlinear one. Furthermore, the Relative Biological Effectiveness (RBE)-values of high Linear Energy Transfer (LET) radiations for residual DSB increase with increasing amount of DSB repair especially in the low dose range. Unrepaired and/or misrepaired DSB are supposed to be responsible for chromosomal aberrations, cell killing, oncogenic cell transformation and gene mutation. At low doses, for these endpoints much higher RBE-values than those for the initial DSB are observed. However, with increasing doses the RBE-values for these endpoints approach those for initial DSB. These observations are likely to be interpreted using the following two parameters of the energy deposition structure: 1. The distribution of clusters with respect to their size at the nm-scale and to the number of ionizations per cluster (cluster distribution). 2. The distribution of distances between clusters of definite size and with definite number of ionizations (distance distribution of clusters). For the induction of DSB solely the ionization density in clusters of nm-dimensions (i.e. the cluster distribution) is important. For unrepaired or misrepaired DSB (responsible for chromosome aberrations, cell killing, oncogenic cell transformation and gene mutation) both the cluster distribution and the distance distribution of clusters are relevant. At low doses the distance distribution of clusters along a single particle track determines the RBE-value. However, with increasing dose the distribution of clusters produced by all particles traversing the cell nucleus becomes increasingly determinant. Here, solely the cluster distribution is important as it is the case for induction of DSB. Author (revised by Herner)

A94-62498

RBE: MECHANISMS INFERRED FROM CYTOGENETICS

E. H. GOODWIN Los Alamos National Laboratory, Los Alamos, NM, US and M. N. CORNFORTH Univ. of Texas, Galveston, TX, US vol. 14, no. 10 October 1994 p. 249-255 Life Sciences and Space Research 25 (2) Radiation Biology: Topical Meeting of the COSPAR Interdisciplinary Scientific Commission F of the COSPAR 29th Plenary Meeting, Washington, DC, Aug. 28-Sep. 5, 1992
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Cyclotron-accelerated heavy ion beams provide a fine degree of control over the physical parameters of radiation. Cytogenetics affords a view into the irradiated cell at the resolution of chromosomes. Combined they form a powerful means to probe the mechanisms of Relative Biological Effectiveness. Cytogenetic studies with high energy heavy ion beams reveal three Linear Energy Transfer (LET)-dependent trends for 1) level of initial damage, 2) distribution of damage among cells, and 3) lesion severity. The number of initial breaks per unit dose increases from a low-LET plateau to a peak at approximately 180 keV/micrometer and declines thereafter. Overdispersion of breaks is significant above approximately 100 keV/micrometer. Lesion severity, indicated by the level of chromosomal fragments that have not restituted even after long repair times, increases with LET. Similar studies with very low energy Pu-238 alpha particles (120 keV/micrometer) reveal higher levels of initial breakage per unit dose, fewer residual fragments and a higher level of misrepair when compared to high energy heavy ions at the same LET. These observations would suggest that track structure is an important factor in genetic damage in addition to LET. Author (revised by Herner)

A94-62499

MUTATION INDUCTION BY HEAVY IONS

J. KIEFER Justus-Liebig Univ., Giessen, DE, U. STOLL Justus-Liebig Univ., Giessen, DE, and E. SCHNEIDER Justus-Liebig Univ., Giessen, DE vol. 14, no. 10 October 1994 p. 257-265 Life Sciences and Space Research 25 (2) Radiation Biology: Topical Meeting of the COSPAR Interdisciplinary Scientific Commission F of the COSPAR 29th Plenary Meeting, Washington, DC, Aug. 28-Sep. 5, 1992 Research sponsored by Gesellschaft fur Schwerionenforschung, Darmstadt.
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Mutation induction by heavy ions is compared in yeast and mammalian cells. Since mutants can only be recovered in survivors the influence of inactivation cross sections has to be taken into account. It is shown that both the size of the sensitive cellular site as well as track structure play an important role. Another parameter which influences the probability of mutation induction is repair: Contrary to naive assumptions primary radiation damage does not directly lead to mutations but requires modification to reconstitute the genetic machinery so that mutants can survive. The molecular structure of mutations was analyzed after exposure to deuterons by amplification with the aid of polymerase chain reaction. The results - although preliminary - demonstrate that even with densely ionizing particles a large fraction does not carry big deletions which suggests that point mutations may also be induced by heavy ions. Author (Herner)

A94-62500 National Aeronautics and Space Administration, Washington, DC.

INDUCTION OF HIGH GRADE ASTROCYTOMA (HGA) BY PROTONS: MOLECULAR MECHANISMS AND RBE CONSIDERATION

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p. 267-270 Life Sciences and Space Research 25 (2) Radiation Biology: Topical Meeting of the COSPAR Interdisciplinary Scientific Commission F of the COSPAR 29th Plenary Meeting, Washington, DC, Aug. 28-Sep. 5, 1992
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Protons of a specific energy, 55 MeV, have been found to induce primary high grade astrocytomas (HGA) in the Rhesus monkey (Macaca mulatta). Brain tumors of this type were not induced by protons of other energies (32 - 2,300 MeV). Induction of HGA has been identified in human patients who have had radiation therapy to the head. We believe that the induction of HGA in the monkey is a consequence of dose distribution, not some unique 'toxic' property of protons. Comparison of the human experience with the monkey data indicates the relative biological effectiveness (RBE) for induction of brain tumors to be about one. It is unlikely that protons cause an unusual change in oncogenic expression, as compared to conventional electromagnetic radiation. Author (revised by Herner)

A94-62501

RELATIVE BIOLOGICAL EFFECTIVENESS AND MICRODOSIMETRY OF A MIXED ENERGY FIELD OF PROTONS UP TO 200 MEV

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We have studied radiation effects utilizing the new 250 MeV Synchrotron at Loma Linda University Medical Center. In this paper we present the data collected for the survival of Chinese hamster lung (V79) cells, that were irradiated with a beam of mixed energy protons up to 200 MeV. The Relative Biological Effectiveness (RBE) for protons, when compared to Co-60 gamma rays, ranged from a low of 1.2 at the high energy portion of the field to 1.3+ at the low energy portion of the field. These results are consistent with the measured lineal energy (microdosimetric) spectra. Author (revised by Herner)

A94-62502

INFLUENCE OF THIOLS AND OXYGEN ON THE SURVIVAL OF GAMMA-IRRADIATED PLASMID DNA AND CELLS

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Some of the recent progress made in the understanding of the quantitative aspects of the oxygen effect in radiation biology by several groups is summarized. Examples are: the importance of unrepairable damage for the quantitative description of the oxygen effect; proof that protein thiols hardly contribute to protection in cells in the absence of oxygen; the proposal that protection by thiols in concentration ranges where all DNA radicals react with oxygen is due to the formation of hydroperoxides which can be repaired enzymatically by glutathione peroxydase; the finding that unscavengeable damage in plasmid DNA is mainly due to spur-induced clustered damages, but that the precursors of the scavengeable and the unscavengeable damage are comparably well repaired by thiols; the result that E. coli repair wild type strains are better protected by addition of thiols than strains with deficiencies in enzymatic repair capacities. Author (Herner)

A94-62503

RADIOBIOLOGY AND PHOTOBIOLOGY ON EARTH AND IN SPACE: POINTS OF ENCOUNTER AND PROTECTION CONSIDERATIONS

E. RIKLIS Nuclear Research Center-Negev, Beer-Sheva, Israel vol. 14, no. 10 October 1994 p. 285-293 Life Sciences and Space Research 25 (2) Radiation Biology: Topical Meeting of the COSPAR Interdisciplinary Scientific Commission F of the COSPAR 29th Plenary Meeting, Washington, DC, Aug. 28-Sep. 5, 1992
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All radiations originate in space, and the spectrum of radiations reaching the troposphere is limited only because of their range and absorption by the ozone layer above the atmosphere. Ultraviolet-C and the very heavy ions are therefore produced on earth only artificially, by special lamps and in accelerators. The range of biological effects of the different ultraviolet (UV) radiations and low and high Linear Energy Transfer (LET) radiations have been studied extensively, yet only recently new facts such as the production of DNA strand breaks by long wave UV light were established, adding to the various points of encounter existing between ionizing and nonionizing radiations. There are some similarities in radiation products, and the resulting effects of insult by radiation on biological systems very often are similar, if not the same. A common phenomenon that exists in all healthy biological cells is the ability to repair damage to DNA and thus either survive or mutate, and although the specific mechanisms of repair are somewhat different, the end result is the same. Recently a mechanism of improved radioprotection was found to involve an effect of certain radioprotective compounds on DNA repair. It is suggested that improved, and nontoxic, modes of protection may be offered by employing such compounds as biological response modifiers and natural substances. Further research is needed and is under way. Author (revised by Herner)

A94-62504

COSMIC RADIATION AND EVOLUTION OF LIFE ON EARTH: ROLES OF ENVIRONMENT, ADAPTATION AND SELECTION

P. TODD Univ. of Colorado, Boulder, CO, US vol. 14, no. 10 October 1994 p. 305-313 Life Sciences and Space Research 25 (2) Radiation Biology: Topical Meeting of the COSPAR Interdisciplinary Scientific Commission F of the COSPAR 29th Plenary Meeting, Washington, DC, Aug. 28-Sep. 5, 1992
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The role of ionizing radiation in general, and cosmic radiation in particular, in the evolution of organisms on the earth by adaptation and natural selection is considered in a series of questions: (1) Are there times during the evolution of the earth and of life when genetic material could be exposed to heavy ion radiation? (2) Throughout the course of chemical and biological evolution on the earth, what fraction of environmental mutagenesis could be attributable to cosmic and/or solar ionizing radiation? (3) Is ionizing radiation an agent of adaptation or selection, or both? (4) What can the cladistics of the evolution of genetic repair tell us about the global history of genotoxic selection pressures? (5) How much genetic diversity can be attributed to the selection of radiation-damage repair processes? Author (Herner)

A94-62505

MUTAGENIC EFFECTS OF HEAVY IONS IN BACTERIA

G. HORNECK Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Koln, DE, E. A. KRASAVIN Joint Institute for Nuclear Research, Dubna, RS, and S. KOZUBEK Institute of Biophysics, Brno, Czech Republic vol. 14, no. 10 October 1994 p. 315-329 Life Sciences and Space Research 25 (2) Radiation Biology: Topical Meeting of the COSPAR Interdisciplinary Scientific Commission F of the COSPAR 29th Plenary Meeting, Washington, DC, Aug. 28-Sep. 5, 1992
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Various mutagenic effects by heavy ions were studied in bacteria, irradiated at accelerators in Dubna, Prague, Berkeley or Darmstadt. Endpoints investigated are histidine reversion (B. subtilis, S. typhi-

murium), azide resistance (B. subtilis), mutation in the lactose operon (E. coli), SOS chromotest (E. coli) and gamma-prophage induction (E. coli). It was found that the cross sections of the different endpoints show a similar dependence on energy. For light ions (Z is less than or equal to 4) the cross section decreases with increasing energy. For ions of Z = 10, it is nearly independent of energy. For heavier ions (Z is greater than or equal to 26) it increases with energy up to a maximum of saturation. The increment becomes steeper with increasing Z. This dependence on energy suggests a 'mutagenic belt' inside the track that is restricted to an area where the density of departed energy is low enough not to kill the cell, but high enough to induce mutations.
Author (revised by Hemer)

A94-62506

MUTATION INDUCTION IN YEAST BY VERY HEAVY IONS

J. KEIFER Justus-Liebig Univ., Giessen, DE vol. 14, no. 10 October 1994 p. 331-338 Life Sciences and Space Research 25 (2) Radiation Biology: Topical Meeting of the COSPAR Interdisciplinary Scientific Commission F of the COSPAR 29th Plenary Meeting, Washington, DC, Aug. 28-Sep. 5, 1992 Sponsored by the Gesellschaft fur Schwerionenforschung (GSI), Darmstadt.
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Resistance to canavanine was studied in haploid yeast after exposure to heavy ions (argon to uranium) of energies between 1 and 10 MeV/u covering a Linear Energy Transfer (LET)-range up to about 10,000 keV/micrometer. Mutations were found in all instances but the induction cross sections increased with ion energy. This is taken to mean that the contribution of penumbra electrons plays an important role. The probability to recover surviving mutants is highest if the cell is not directly hit by the particle. The experiments demonstrate that the geometrical dimensions of the target cell nucleus as well as its sensitivity in terms of survival have a critical influence on mutation induction with very heavy ions. Author (revised by Hemer)

A94-62508* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.

CHARGED-PARTICLE MUTAGENESIS 2. MUTAGENIC EFFECTS OF HIGH ENERGY CHARGED PARTICLES IN NORMAL HUMAN FIBROBLASTS

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The biological effects of high Linear Energy Transfer (LET) charged particles are a subject of great concern with regard to the prediction of radiation risk in space. In this report, mutagenic effects of high LET charged particles are quantitatively measured using primary cultures of human skin fibroblasts, and the spectrum of induced mutations are analyzed. The LET of the charged particles ranged from 25 KeV/micrometer to 975 KeV/micrometer with particle energy (on the cells) between 94-603 MeV/u. The X-chromosome linked hypoxanthine guanine phosphoribosyl transferase (hprt) locus was used as the target gene. Exposure to these high LET charged particles resulted in exponential survival curves; whereas, mutation induction was fitted by a linear model. The Relative Biological Effect (RBE) for cell-killing ranged from 3.73 to 1.25, while that for mutant induction ranged from 5.74 to 0.48. Maximum RBE values were obtained at the LET of 150 keV/micrometer. The inactivation cross-section (alpha i) and the action cross-section for mutant induction (alpha m) ranged from 2.2 to 92.0 sq micrometer and 0.09 to 5.56 x 10(exp -3) sq micrometer respectively. The maximum values were obtained by Fe-56 with an LET of 200 keV/micrometer. The mutagenicity (alpha m/alpha i) ranged from 2.05 to 7.99 x 10(exp -5) with the maximum value at 150 keV/micrometer. Furthermore, molecular analysis of mutants induced by charged particles indicates that higher LET beams are more likely to cause larger deletions in the hprt locus. Author (revised by Hemer)

A94-62509

MOLECULAR ANALYSIS OF MUTAGENESIS BY HIGH LET RADIATION

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(Contract CA-49062; CA-36447; CA-56392)
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Mutation induction by high linear energy transfer (LET) alpha particles and gamma-rays was scored in the human hamster hybrid (AL) cells. Southern blotting technique was used to analyse the molecular changes in the DNA from both the HGPRT(-) and S1(-) mutants. Dose dependent mutagenesis in the (AL) cells irradiated with the charged particles was higher by almost 20 fold at the S1 than the corresponding HGPRT locus. Southern analysis of the mutants induced by the high LET particles showed mostly multilocus deletion at both the HGPRT and S1 genes. Author (revised by Hemer)

A94-62510* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.

MUTAGENIC EFFECTS OF HEAVY ION RADIATION IN PLANTS

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Genetic and developmental effects of heavy ions in maize and rice were investigated. Heavy particles with various charges and energies were accelerated at the BEVALAC. The frequency of occurrence of white-yellow stripes on leaves of plants developed from irradiated maize seeds increased linearly with dose, and high Linear Energy Transfer (LET) heavy charged particles, e.g., neon, argon, and iron, were 2-12 times as effective as gamma rays in inducing this type of mutation. The effectiveness of high-LET heavy ion in (1) inhibiting rice seedling growth, (2) reducing plant fertility, (3) inducing chromosome aberration and micronuclei in root tip cells and pollen mother cells of the first generation plants developed from exposed seeds, and (4) inducing mutation in the second generation, were greater than that of low-LET gamma rays. All effects observed were dose-dependent; however, there appeared to be an optimal range of doses for inducing certain types of mutation, for example, for argon ions (400 MeV/u) at 90-100 Gy, several valuable mutant lines with favorable characters, such as semidwarf, early maturity and high yield ability, were obtained. Experimental results suggest that the potential application of heavy ions in crop improvement is promising. Restriction-fragment-length-polymorphism (RFLP) analysis of two semidwarf mutants induced by argon particles revealed that large DNA alterations might be involved in these mutants. Author (revised by Herner)

A94-62511* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.

HEAVY-ION INDUCED GENETIC CHANGES AND EVOLUTION PROCESSES

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On Moon and Mars, there will be more galactic cosmic rays and higher radiation doses than on Earth. Our experimental studies showed that heavy ion radiation can effectively cause mutation and chromosome aberrations and that high Linear Energy Transfer (LET) heavy-ion induced mutants can be irreversible. Chromosome translocations and deletions are common in cells irradiated by heavy particles, and ionizing radiations are effective in causing hyperploidy. The importance of the genetic changes in the evolution of life is an interesting question. Through evolution, there is an increase of DNA content in cells from lower forms of life to higher organisms. The DNA content, however, reached a plateau in vertebrates. By increasing DNA content, there can be an increase of information in the cell. For a given DNA content, the quality of information can be changed by rearranging the DNA. Because radiation can cause hyperploidy, an increase of DNA content in cells, and can induce DNA rearrangement, it is likely that the evolution of life on Mars will be effected by its radiation environment. A simple analysis shows that the radiation level on Mars may cause a mutation frequency comparable to that of the spontaneous mutation rate on Earth. To the extent that mutation plays a role in adaptation, radiation alone on Mars may thus provide sufficient mutation for the evolution of life.
Author (revised by Herner)

A94-62512

INITIAL APPROACH TO COMPARATIVE STUDIES ON THE EVOLUTIONARY POTENTIALS OF SPACE RADIATION EFFECTS IN A PLANT SYSTEM

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The role of cosmic ionizing radiation, including heavy ions (HZE-particles) in the induction of mutations at the molecule-, chromosome-, genome- and cell-level is discussed on the basis of different DNA organization in a pro- and eukaryotically compartmented plant system (Arabidopsis thaliana (L.) Heynh.). Recently obtained data on the biological effects of ionizing radiation make it timely to discuss comparatively the evolutionary potentials of space radiation effects in the pro- and eukaryotic genomes (plasmon, plastidom, chondriom, and nucleom) during long duration exposure on space flights.
Author (Herner)

A94-62513

DICTYOSTELIUM DISCOIDEUM, A LOWER EUKARYOTE MODEL FOR THE STUDY OF DNA REPAIR: IMPLICATIONS FOR THE ROLE OF DNA-DAMAGING CHEMICALS IN THE EVOLUTION OF REPAIR PROFICIENT CELLS

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The evolution of the ability of living cells to cope with stress is crucial for the maintenance of their genetic integrity. Yet low levels of mutation must remain to allow adaptation to environmental changes. The cellular slime mold D. discoideum is a good system for studying molecular aspects of the repair of lethal and mutagenic damage to DNA by radiation and chemicals. The wild-type strains of this soil microorganism are extremely resistant to DNA damaging agents. In nature the amoeboid cells in their replicative stage feed on soil bacteria and are exposed to numerous DNA-damaging chemicals produced by various soil microorganisms. It is probable that the evolution of repair systems in this organism and perhaps in others is a consequence of the necessity to cope with chemical damage which also confers resistance to radiation.
Author (Herner)

A94-62514

OVERVIEW ON EXPERIENCE TO DATE ON HUMAN EXPOSURE TO SPACE RADIATIONS

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The human exposure in space depends on the three factors: the flight trajectory, its date and duration and the cyclogram of the cosmonaut's activities. In the near-Earth orbits the daily dose varies within the limits of (1.5-5.0) times 10(exp -4) Gy/day end greatly increases if the altitude increases. The mean daily quality factor is 1.6-2.0. Strong solar proton events in the orbits with the inclination of less than 52 deg result in the dose rate increase up to 2-3 cGy/day. On the surface of the orbital spacecrafts the daily dose reaches 2 Gy. The neutron dose depends on the shielding mass distribution varying within the limits of 6%-30% of the charged particles dose. In deep space the dose is mainly formed by the galactic and solar cosmic rays (GCR, SCR). Behind the shielding of 2-3 g/sq cm Al the GCR dose varies in the range of (20-30) times 10(exp -5) Gy/day. The SCR dose can reach hundreds of cSv. Author (revised by Herner)

A94-62519

HISTOLOGIC EFFECTS OF HIGH ENERGY ELECTRON AND PROTON IRRADIATION OF RAT BRAIN DETECTED WITH A SILVER-DEGENERATION STAIN

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Application of the degeneration sensitive, cupric-silver staining method to brain sections of male Sprague-Dawley rats irradiated 4 days before sacrifice with 155 Mev protons, 2-8 Gy at 1 Gy/min (N=6) or 22-101Gy at 20 Gy/min (n=16) or with 18.6 Mev electrons, 32-67 Gy at 20 Gy/min (n=20), doses which elicit behavioral changes (accelerod or conditioned taste aversion), resulted in a display of degeneration of astrocyte-like cell profiles which were not uniformly distributed. Plots of 'degeneration scores' (counts of profiles in 29 areas) vs. dose for the proton and electron irradiations displayed a linear dose response for

protons in the range of 2-8 Gy. In the 20-100 Gy range, for both electrons and protons the points were distributed in a broad band suggesting a saturation curve. The dose range in which these astrocyte-like profiles becomes maximal corresponds well with the dose range for the X-ray eradication of a subtype of astrocytes, 'beta astrocytes'.
Author (Hemer)

A94-62520

RADIATION CHEMISTRY OF THE HIPPOCAMPAL BRAIN SLICE

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The in vitro hippocampal brain slice is a 0.4 mm thick neural network that can be used to study brain responses to radiation and related injuries. This preparation is unique in that it responds to ionizing radiation within minutes after exposure without complications from changes in vascularity, blood flow, blood pressure, etc. Electrophysiological studies have shown that x- and gamma-rays alter synaptic transmission and spike generation, elements of normal brain activity. To evaluate the role of hydroxyl free radicals in these changes, slices were exposed to dilute H2O2 solutions. Electron Paramagnetic Resonance (EPR) spin trapping experiments verified that OH free radical is produced. Neural responses, while similar, were not identical to those due to radiation, possibly because of a different distribution of OH free radical. Although H2O2 is freely diffusible, it produces OH free radical at specific sites where, e.g. iron reduces it. In contrast, x- and gamma-rays produce OH free radical more uniformly throughout the tissue. H2O2 may provide a better model for high-Linear Energy Transfer (LET) radiation where yields of radical products of water radiolysis are decreased and peroxide reactions predominate.
Author (revised by Hemer)

A94-62521

BEHAVIORAL ENDPOINTS FOR RADIATION INJURY

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The relative behavioral effectiveness of heavy particles was evaluated. Using the taste aversion paradigm in rats, the behavioral toxicity of most type of radiation (including Ne-20 and Ar-40) was similar to that of Co-60 photons. Only Fe-56 and Nb-93 particles and fission neutrons were significantly more effective. Using emesis in ferrets as the behavioral endpoint, Fe-56 particles and neutrons were again the most effective; however, Co-60 photons were significantly more effective than 18 MeV electrons. These results suggest that Linear Energy Transfer (LET) does not completely predict behavioral effectiveness. Additionally, exposing rats to 10 cGy of Fe-56 particles attenuated amphetamine-induced taste aversion learning. This behavior is one of a broad class of behaviors which depends on the integrity of the dopaminergic system and suggests the possibility of alterations in these behaviors following exposure to heavy particles in a space radiation environment. Author (revised by Hemer)

A94-62522* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.

NEURITOGENESIS: A MODEL FOR SPACE RADIATION EFFECTS ON THE CENTRAL NERVOUS SYSTEM

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Pivotal to the astronauts' functional integrity and survival during long space flights are the strategies to deal with space radiations. The majority of the cellular studies in this area emphasize simple endpoints such as growth related events which, although useful to understand the nature of primary cell injury, have poor predictive value for extrapolation to more complex tissues such as the central nervous system (CNS). In order to assess the radiation damage on neural cell populations, we developed an in vitro model in which neuronal differentiation, neurite extension, and synaptogenesis occur under controlled conditions. The model exploits chick embryo neural explants to study the effects of radiations on neuritogenesis. In addition, neurobiological problems associated with long-term space flights are discussed.
Author (Hemer)

A94-62523* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.

THE INFLUENCE OF DOSE, DOSE-RATE AND PARTICLE FRAGMENTATION ON CATARACT INDUCTION BY ENERGETIC IRON IONS

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(Contract T5328R; W17,468; NAG9-256-52; DOE-DE-FG02-90ER6009; FG02-88ER60631; EY02648)
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Because activities in space necessarily involve chronic exposure to a heterogeneous charged particle radiation field it is important to assess the influence of dose-rate and the possible modulating role of heavy particle fragmentation on biological systems. Using the well-studied cataract model, mice were exposed to plateau 600 MeV/amu Fe-56 ions either as acute or fractionated exposures at total doses of 5-504 cGy. Additional groups of mice received 20, 360 and 504 cGy behind 50 mm of polyethylene, which simulates body shielding. The reference radiation consisted of Co-60 gamma radiation. The animals were examined by slit lamp biomicroscopy over their three year life spans. In accordance with our previous observations with heavy particles, the cataractogenic potential of the 600 MeV/amu Fe-56 ions was greater than for low-Linear Energy Transfer (LET) radiation and increased with decreasing dose relative to gamma rays. Fractionation of a given dose of Fe-56 ions did not reduce the cataractogenicity of the radiation compared to the acute regimen. Fragmentation of the beam in the polyethylene did not alter the cataractotoxicity of the ions, either when administered singly or in fractions. Author (revised by Hemer)

A94-62524

RADIATION EFFECTS ON LATE CYTOPATHOLOGICAL PARAMETERS IN THE MURINE LENS RELATIVE TO PARTICLE FLUENCE

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Lenses of mice irradiated with 250 MeV protons, 670 MeV/amu Ne-20, 600 MeV/amu Fe-56, 600 MeV/amu Nb-93 and 593 MeV/amu La-139 ions were evaluated by analyzing cytopathological indicators which have been implicated in the cataractogenic process. The Linear Energy Transfers (LETs) ranged from 0.40 keV/micrometer to 953 keV/micrometer and fluences from 1.31 x 10(exp 3)/sq mm to 4.99 x 10(exp 7)/sq mm. Co-60 gamma-rays were used as the reference radiation. The doses ranged from 10 to 40 cGy. The lenses were assessed 64 weeks post irradiation in order to observe the late effects of LET and dose on the target cell population of the lens epithelium.

Author (revised by Herner)

A94-62525* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.

NON-SUBJECTIVE CATARACT ANALYSIS AND ITS APPLICATION IN SPACE RADIATION RISK ASSESSMENT

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Experimental animal studies and human observations suggest that the question is not whether or not prolonged space missions will cause cataracts to appear prematurely in the astronauts, but when and to what degree. Historically the major impediment to radiation cataract follow-up has been the necessarily subjective nature of assessing the degree of lens transparency. This has spurred the development of instruments which produce video images amenable to digital analysis. One such system, the Zeiss Scheimpflug slit lamp measuring system (SLC), was incorporated into our ongoing studies of radiation cataractogenesis. It was found that the Zeiss SLC measuring system has high resolution and permits the acquisition of reproducible images of the anterior segment of the eye. Our results, based on about 650 images of the rats lens, and followed over a period of 91 weeks of radiation cataract development, showed that the integrated Optical Density (IOD) of the lens correlated well with conventional assessment with the added advantages of objectivity, permanent and transportable records and linearity as cataracts become more severe. This continuous data acquisition, commencing with cataract onset, can proceed through more advanced stages. The SLC exhibits much greater sensitivity reflected in a continuously progressive severity despite the artifactual plateaus in staging which occur using conventional scoring methods. Systems such as the Zeiss SLC should be used to monitor astronauts frequent visits to low earth orbit to obtain a longitudinal database on the influence of this activity on the lens. Author (Herner)

A94-62527

ESTIMATION OF RISK BASED ON MULTIPLE EVENTS IN RADIATION CARCINOGENESIS OF RAT SKIN

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(Contract CA-43199)

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In the multistage theory of carcinogenesis, cells progress to cancer through a series of discrete, irreversible, heritable genetic alterations or mutations. However data on radiation-induced cancer incidence in rat skin suggests that some part of an intermediate repairable alteration may occur. Data are presented on cancer induction in rat skin exposed to the following radiations: 1. an electron beam Linear Energy Transfer (LET) = 0.34 keV/micrometer, 2. a neon ion beam (LET = 25 keV/micrometer and 3. an argon ion beam (LET = 125 keV/micrometer. The latter 2 beams were generated by the Bevalac at the Lawrence Berkeley Laboratory, Berkeley, CA. About 6.0 sq cm of skin was irradiated per rat. The rats were observed every 6 weeks for at least 78 weeks and tumors were scored at first occurrence. Several histological types of cancer, including squamous and basal cell carcinomas, were induced. The cancer yield versus radiation dose was fitted by the quadratic equation (Y(D)=CLD+BD sq), and the parameters C and B were estimated for each type of radiation. Analysis of the DNA from the electron-induced carcinomas indicated that K-ras and/or c-myc oncogenes were activated in all tumors tested, although only a small proportion of neon-induced tumors showed similar activation. In situ hybridization indicated that the cancers contain subpopulations of cells with differing amounts of c-myc and H-ras amplification. The results are consistent with the idea that ionizing radiation produces carcinogenically relevant lesions via 2 repairable events at low LET and via a non-repairable, linked event pathway at high LET; either pathway may advance the cell by 1 stage in the multistage model. The model, if validated, permits the direct calculation of cancer risk in rat skin in a way that can be subjected to experimental testing.

Author (revised by Herner)

A94-62528

HEAVY ION INDUCED CHANGES IN SMALL INTESTINAL PARAMETERS

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The effects on 17 different structural parameters of mouse small intestine three days after treatment with three types of heavy ion (neon, iron and niobium) are compared, the first two being of particular relevance to space flight. The data for niobium are given in full, showing that changes after niobium ion treatment are not standard and are concentrated in the epithelial compartment, with few of the parameters having a response which is dose dependent. When comparisons are made for the three types of heavy ion, the damage is greatest after neon ion irradiation, implying that the additional non-epithelial damage produced as Linear Energy Transfer (LET) rises from X rays through neutrons to neon ions is not necessarily maintained as LET continues to rise. Further understanding is therefore needed of the balance between changes affecting the vascular and absorptive components of the organ. Variation from group to group is also important, as is variation of strain or gastrointestinal status. All such factors are important in the understanding of changes in multicellular organs after exposure to heavy ion radiation. Author (revised by Herner)

A94-62529

CHANGES IN WHOLE-BODY METABOLIC PARAMETERS ASSOCIATED WITH RADIATION

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Continuous irradiation of experimental animals is an appropriate model for the research in space radiobiology. The onset and recovery of radiation injury can be estimated on the basis of the concentration/content of glycogen in liver, the phospholipid content in thymus and other radiosensitive organs and the triacylglycerol concentration in bone marrow. Further, the picture of the metabolism in irradiated organism may be completed by the analysis of serum glucocorticoid and thyroid hormone levels. Author (Herner)

A94-62531

POTENTIAL VASCULAR DAMAGE FROM RADIATION IN THE SPACE ENVIRONMENT

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Cultured endothelial cells of blood vessels have a Do of 2 Gy for X-rays. A dose of 0.5 Gy of X-rays has an acute affect on vessel diameter. The vessels may show other acute effects such as change in permeability including a change in the blood brain barrier. Changes occurring from late effects of chronic exposure in vascular architecture include telangiectasia and decrease in vascular density. Changes in the perivascular connective tissue particularly collagen may play a role in these changes. After charged particle exposure of 15 and 30 Gy, radiation changes in the blood brain barrier and vascular changes are noted in the nervous system. These long term changes are recorded by Positron Emission Tomography (PET), Magnetic Resonance Imaging (MRI), and Computerized Tomography (CT) imaging. Chronic exposure to alpha particles causes vascular damage in compact bone resulting in bone infarcts. Using tandem scanning confocal microscopy in-situ imaging of the capillaries and collagen of the papillary dermis provides a non-invasive method of serial recording of changes in irradiated microvasculature. Author (revised by Herner)

A94-62532

EFFECTS OF RADIATION ON RAT RESPIRATORY EPITHELIAL CELLS: CRITICAL TARGET CELL POPULATIONS AND THE IMPORTANCE OF CELL-CELL INTERACTIONS

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The oncongenic effects of radiation on rat respiratory tissues are modulated in vivo within the intact tissue. The degree of modulation as well as the mechanism whereby modulation occurs appears to be different for different types of ionizing radiations. A combined cell culture in vivo model is described. This model has been developed to evaluate the influence of the host and tissue environment on development and expression of the neoplastic phenotype in irradiated rat trachea. Our data indicates that the potentially oncogenic effects of neutrons, X Rays, and alpha particles are different depending on the exposure conditions employed and the conditions under which exposed cells are maintained following exposure.
Author (revised by Herner)

A94-62533* National Aeronautics and Space Administration, Washington, DC.

FLUENCE-BASED RELATIVE BIOLOGICAL EFFECTIVENESS FOR CHARGED PARTICLE CARCINOGENESIS IN MOUSE HARDERIAN GLAND

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(Contract T1931M; DE-AC03-76SF00098; DE-AC05-85OR21400)
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Neoplasia in the rodent Harderian gland has been used to determine the carcinogenic potential of irradiation by HZE particles. Ions from protons to lanthanum at energies up to 670 MeV/a have been used to irradiate mice, and prevalence of Harderian gland tumors has been measured 16 months after irradiation. The Relative Biological Effectiveness (RBE) for tumor induction has been expressed as the RBE(sub max), which is the ratio of the initial slopes of the dose vs prevalence curve. The RBE(sub max) has been found to be approximately 30 for ions with Linear Energy Transfer (LET) values in excess of 100 keV/micrometer. Analysis on the basis of fluence as a substitute for dose has shown that on a per particle basis all of the ions with LET values in excess of 100 keV/micrometer have equal effectiveness. An analysis of the probabilities of ion traversals of the nucleus has shown that for these high stopping powers that a single hit is effective in producing neoplastic transformation. Author (revised by Herner)

A94-62534

SURVIVAL OF IRRADIATED MICE TREATED WITH WR-151327, SYNTHETIC TREHALOSE DICORYNOMYCOLATE, OR OFLOXACIN

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Spaceflight personnel need treatment options that would enhance survival from radiation and would not disrupt task performance. Doses of prophylactic or therapeutic agents known to induce significant short-term (30-day) survival with minimal behavioral (locomotor) changes were used for 180-day survival studies. In protection studies, groups of mice were treated with the phosphorothioate WR-151327 (200 mg/kg, 25% of the LD10 or the immunomodulator, synthetic trehalose dicorynomycolate (S-TDCM; 8 mg/kg), before lethal irradiation with reactor-generated fission neutrons and gamma-rays (n/gamma=1) or Co-60 gamma-rays. In therapy studies, groups of mice received either S-TDCM, the antimicrobial ofloxacin, or S-TDCM plus ofloxacin after irradiation. For WR-151327 treated-mice, survival at 180 days for n/gamma=1 and gamma-irradiated mice was 90% and 92%, respectively; for S-TDCM (protection), 57% and 78%, respectively; for S-TDCM (therapy), 20% and 25%, respectively; for ofloxacin, 38% and 5%, respectively; for S-TDCM combined with ofloxacin, 30% and 30%, respectively; and for saline, 8% and 5%, respectively. Ofloxacin or combined ofloxacin and S-TDCM increased survival from the gram-negative bacterial sepsis that predominated in n/gamma=1 irradiated mice. The efficacies of the treatments depended on radiation quality, treatment agent and its mode of use, and microflora of the host.

Author (revised by Herner)

A94-62547

HEAD AND NECK TUMORS AFTER ENERGETIC PROTON IRRADIATION IN RATS

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This is a two-year progress report on a life span dose-response study of brain tumor risk at moderate to high doses of energetic protons. It was initiated because a joint NASA/USAF life span study of rhesus monkeys that were irradiated with 55-MeV protons (average surface dose, 3.5 Gy) indicated that the incidence of brain tumors per unit surface absorbed dose was over 19 times that of the human tines capitis patients whose heads were exposed to 100 kv x-rays. Examination of those rats that died in the two-year interval after irradiation of the head revealed a linear dose-response for total head and neck tumor incidence in the dose range of 0-8.5 Gy. The exposed rats had a greater incidence of pituitary chromophobe adenomas, epithelial and mesothelial cell tumors than the unexposed controls but the excessive occurrence of malignant gliomas that was observed in the monkeys was absent in the rats. The estimated dose required to double the number of all types of head and neck tumors was 5.2 Gy. The highest dose, 18 Gy, resulted in high mortality due to obstructive squamous metaplasia at less than 50 weeks, prompting a new study of the relative biological effectiveness of high energy protons in producing this lesion.

Author (Herner)

A94-62575

AN INDUCTIVE ASSESSMENT OF RADIATION RISKS IN SPACE

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Procedures for the assessment of risks or vulnerabilities from radiation in space are evaluated in terms of model-independent inductive approaches. The reliablity of risks calculated for space applications on the basis of accelerator-based physical and biological data is examined from a microdosimetric perspective. Probability distributions for energy deposition in biologically significant sites extend over several decades in lineal energy even for monoenergetic high-energy particles of relatively high atomic number. Because the response depends on a large number of variables and because of the difficulty of incorporating all such factors into calculations, a precise correlation between a physical descriptor of the field and observed effects in space is not feasible. For the same reasons, it is equally difficult to estimate the accuracies of each risk assessments. We use recently published microdosimetric spectra for HZE particles and biological weighting functions, including those derived from biological measurements with maximum entropy techniques, to illustrate some problems associated with the evaluations of risks from radiation fields in space.

Author (Herner)

A94-62580* National Aeronautics and Space Administration. Goddard Inst. for Space Studies, New York, NY.

UNCERTAINTIES IN RADIATION EFFECT PREDICTIONS FOR THE NATURAL RADIATION ENVIRONMENTS OF SPACE

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Future manned missions beyond low earth orbit require accurate predictions of the risk to astronauts and to critical systems from exposure to ionizing radiation. For low-level exposures, the hazards are dominated by rare single-event phenomena where individual cosmic-ray particles or spallation reactions result in potentially catastrophic changes in critical components. Examples might be a biological lesion leading to cancer in an astronaut or a memory upset leading to an undesired rocket firing. The risks of such events appears to depend on the amount of energy deposited within critical sensitive volumes of biological cells and microelectronic components. The critical environmental information needed to estimate the risks posed by the natural space environments, including solar flares, is the number of times more than a threshold amount of energy for an event will be deposited in the critical microvolumes. These predictions are complicated by uncertainties in the natural environments, particularly the composition of flares, and by the effects of shielding. Microdosimetric data for large numbers of orbits are needed to improve the environmental models and to test the transport codes used to predict event rates. Author (Herner)

A94-62581

EXPERIMENTAL SIMULATION OF PROTON SPACE RADIATION ENVIRONMENTS: A DOSIMETRIC PERSPECTIVE

K. A. HARDY USAF Armstrong Laboratory, Brooks AFB, TX, USA and D. D. LEAVITT University of Utah Medical Center, Salt Lake City, UT, USA vol. 14, no. 10 October 1994 p. 959-967 Life Sciences and Space Research 25 (2) Radiation Biology: Topical Meeting of the COSPAR Interdisciplinary Scientific Commission F of the COSPAR 29th Plenary Meeting, Washington, DC, Aug. 28-Sep. 5, 1992

(Contract F-33615-87-D-0627; F-33615-87-D-0005; F-33615-87-D-0009)

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Three-dimensional dose calculation techniques developed for radiotherapy treatment planning were used to calculate dose distributions from unidirectional, planar rotational and omnidirectional incident radiation (experimental proton beams and solar flares). The calculations predicted regions for high dose within primate heads exposed to 55-MeV protons, supporting the postulate of radiation-induced brain tumors within this population. Comparisons among predicted doses to the human head from solar flares of three different energies demonstrated differences between unidirectional and omnidirectional irradiation in the space environment. The results can be used to estimate dose distributions based on: a) limited phantom measurements, or b) nonuniformly incident radiation in orbit; both simulations are difficult to replicate under laboratory exposure conditions.

Author (revised by Herner)

A94-62585

ON THE PARAMETRIZATION OF THE BIOLOGICAL EFFECT IN A MIXED RADIATION FIELD

G. KRAFT Biophysik - GSI, Darmstadt, Germany and M. SCHOLZ Biophysik - GSI, Darmstadt, Germany vol. 14, no. 10 October 1994 p. 997-1004 Life Sciences and Space Research 25 (2) Radiation

Biology: Topical Meeting of the COSPAR Interdisciplinary Scientific Commission F of the COSPAR 29th Plenary Meeting, Washington, DC, Aug. 28-Sep. 5, 1992
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The exposure of astronauts and electronics to the cosmic radiation especially to the particle component poses a major risk to all space flights. Up to now it is not possible to quantify this risk within acceptable limits of accuracy. This uncertainty is not only caused by difficulties in the more or less exact prediction of the incidence of the cosmic radiation but depends also on the problem of the quantification of the radiation field and the correlation of the biological effect. Usually the biological action of a mixed radiation field is estimated as product of the measured dose with an average quality factor, the relative biological efficiency. Because of the large variation in energy and atomic number of the cosmic particles, average values of the quality factor are not precise for risk estimation. A more appropriate way to treat the biological effects of mixed radiation is the concept of particle fluence and action cross section. Author (revised by Herner)

A94-62587

BIOPHYSICAL EFFECT OF COSMIC HEAVY IONS OF DISTINCT LET-CLASSES IN A PLANT MODEL SYSTEM

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Results presented from recent space flight BION 9 show biological effects of different Linear Energy Transfer (LET)-classes of HZE-particles in different target regions of the seed (meristem and the whole embryo) of Arabidopsis thaliana (L.) Heyhn. HZE-one hitevents and non-hitevents, i.e. only hit by the low-LET background radiation, and their combined effects on the biological damage endpoint lethality are distinguished. This procedure is opening the opportunity of an approach to comparative studies of the biological effects induced by cosmic HZE-particles of different LET-ranges interacting in the complex cosmic radiation spectrum and with other space flight conditions.
Author (revised by Herner)

A94-62588

INACTIVATION OF INDIVIDUAL BACILLUS SUBTILIS SPORES IN DEPENDENCE ON THEIR DISTANCE TO SINGLE COSMIC HEAVY IONS

R. FACIUS Institute for Aerospace Medicine, Germany, G. REITZ Institute for Aerospace Medicine, Germany, and M. SCHAFER Institute for Aerospace Medicine, Germany vol. 14, no. 10 October 1994 p. 1027-1038 Life Sciences and Space Research 25 (2) Radiation Biology: Topical Meeting of the COSPAR Interdisciplinary Scientific Commission F of the COSPAR 29th Plenary Meeting, Washington, DC, Aug. 28-Sep. 5, 1992
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For radiobiological experiments in space, designed to investigate biological effects of the heavy ions of the cosmic radiation field, a mandatory requirement is the possibility to spatially correlate the observed biological response of individual test organisms to the passage of single heavy ions. Among several undertaking towards this goal, the BIOSTACK experiments in the Apollo missions achieved the highest precision and therefore the most detailed information on this question. Spores of Bacillus subtilis as a highly radiation resistant and microscopically small test organism yielded these quantitative results. This paper will focus on experimental and procedural details, which must be included for an interpretation and a discussion of these findings in comparison to control experiments with accelerated heavy ions.
Author (Herner)

A94-62589

INACTIVATION OF INDIVIDUAL BACILLUS SUBTILIS SPORES IN DEPENDENCE ON THEIR DISTANCE TO SINGLE ACCELERATED HEAVY IONS

M. SCHAFER DLR, FF-ME Biophysik, Germany, R. FARCIUS DLR, FF-ME Biophysik, Germany, and G. REITZ DLR, FF-ME Biophysik, Germany vol. 14, no. 10 October 1994 p. 1039-1046 Life Sciences and Space Research 25 (2) Radiation Biology: Topical Meeting of the COSPAR Interdisciplinary Scientific Commission F of the COSPAR 29th Plenary Meeting, Washington, DC, Aug. 28-Sep. 5, 1992
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In order to understand radiation mechanisms of heavy ions in detail, it is necessary to study effects of single ions on individual biological test objects. Spores of Bacillus subtilis have been used as a suitable small biological test system to measure the inactivation in dependence on the radial distance to the tracks of charged particles. Accelerator experiments have been performed using a modified Biostack technique- biological objects sandwiched between nuclear track detectors. Results of these experiments using ions differing in their energy and atomic number will be discussed under the following aspects: (1) mathodological differences between the experiments and their possible influences on the results, (2) common features which are independent on the particle type and energy, (3) theoretical expectations and problems to find solid theoretical concepts which explain the results.
Author (Herner)

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AEROSPACE MEDICINE

Includes physiological factors; biological effects of radiation; and effects of weightlessness on man and animals.

A94-62468* National Aeronautics and Space Administration, Washington, DC.

LIFE SCIENCES AND SPACE RESEARCH 25 (2) RADIATION BIOLOGY: TOPICAL MEETING OF THE COSPAR INTERDISCIPLINARY SCIENTIFIC COMMISSION F OF THE COSPAR 29TH PLENARY MEETING, WASHINGTON, DC, AUG. 28-SEP. 5, 1992

G. HORNECK, editor Institute of Aerospace Medicine, Cologne, Germany, H. BUECHER, editor Institute of Aerospace Medicine, Cologne, Germany, A. COX, editor AL/OERD, Brooks AFB, TX, US, P. TODD, editor Colorado Univ., Boulder, CO, US, T. C. YANG, editor NASA. Johnson Space Center, Houston, TX, US, B. V. WORGUL, editor Columbia Univ., New York, NY, US, M. DONLON, editor Armed Forces Radiobiology Research In Bethesda, Bethesda, MD, US, W. ATWELL, editor Rockwell International, Houston, TX, US, M. A. SHEA, editor Phillips Lab., Hanscom AFB, Bedford, MA, US, D. F. SMART, editor Phillips Lab., Hanscom AFB, Bedford, MA, US et al. vol. 14, no. 10 October 1994 p. 1-1050
(ISBN 0-08-042487-2; HTN-94-00500) Copyright

Papers presented on long-term exposure to ionizing radiation, obtained from the Long Duration Exposure Facility, included radiation monitoring, radiation effects, and dosimetry. Mechanisms of biological systems, especially cells, under ionizing radiation and relative biological effectiveness were compared. The role of HZE particles as agents of mutation were reported from plant, animal, and in vitro models. Data on known and predicted effects of cosmic rays and other solar radiation on biological systems included differences related to Linear Energy Transfer and heavy ion particles. Herner

A94-62484* National Aeronautics and Space Administration, Washington, DC.

DEVELOPMENT OF HUMAN EPITHELIAL CELL SYSTEMS FOR RADIATION RISK ASSESSMENT

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and L. M. CRAISE Lawrence Berkeley Laboratory, Berkeley, CA, US vol. 14, no. 10 October 1994 p. 115-120 Life Sciences and Space Research 25 (2) Radiation Biology: Topical Meeting of the COSPAR Interdisciplinary Scientific Commission F of the COSPAR 29th Plenary Meeting, Washington, DC, Aug. 28-Sep. 5, 1992
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The most important health effect of space radiation for astronauts is cancer induction. For radiation risk assessment, an understanding of carcinogenic effect of heavy ions in human cells is most essential. In our laboratory, we have successfully developed a human mammary epithelial cell system for studying the neoplastic transformation in vitro. Growth variants were obtained from heavy ion irradiated immortal mammary cell line. These cloned growth variants can grow in regular tissue culture media and maintain anchorage dependent growth and density inhibition property. Upon further irradiation with high-Linear Energy Transfer (LET) radiation, transformed foci were found. Experimental results from these studies suggest that multiexposure of radiation is required to induce neoplastic tranformation of human epithelial cells. This multihits requirement may be due to high genomic stability of human cells. These growth variants can be useful model systems for space flight experiments to determine the carcinogenic effect of space radiation in human epithelial cells.
Author (revised by Herner)

A94-62485* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

DOSE RATE AND REPAIR EFFECTS ON CELL DAMAGE IN EARTH ORBIT

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Radiobiology experiments performed in space will encounter continuous exposures to the cosmic rays and fractionated exposures to trapped protons which accumulate to several hundred dose fractions in a few weeks. Using models of track structure and cellular kinetics combined with models of the radiation environment and radiation transport, we consider calculations of damage rates for cell cultures. Analysis of the role of repair mechanisms for space exposures for the endpoints of survival and transformation is emphasized.
Author (Herner)

A94-62507 National Aeronautics and Space Administration, Washington, DC.

MUTATION INDUCTION IN HUMAN LYMPHOID CELLS BY ENERGETIC HEAVY IONS

A. KRONENBERG Lawrence Berkeley Laboratory, Berkeley, CA, US vol. 14, no. 10 October 1994 p. 339-346 Life Sciences and Space Research 25 (2) Radiation Biology: Topical Meeting of the COSPAR Interdisciplinary Scientific Commission F of the COSPAR 29th Plenary Meeting, Washington, DC, Aug. 28-Sep. 5, 1992
(Contract T-9309; NIH R29 GM 4317803)
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One of the concerns for extended space flight outside the magnetosphere is exposure to galactic cosmic radiation. In the series of studies presented herein, the mutagenic effectiveness of high energy heavy ions is examined using human lymphoblastoid cells across an Linear Energy Transfer (LET) range [illegible] 32keV/micrometer to 190 keV/micrometer. Mutations were scored for an autosomal locus, thymidine kinase (tk), and for an X-linked locus, hypoxanthine phosphoribosyltransferase (hprt). For each of the radiations studied, the autosomal locus is more sensitive to mutation induction than is the X-linked locus. When mutational yields are expressed in terms of particle fluence, the two loci respond quite differently across the range of LET. The action cross section for mutation induction peaks at 61 keV/micrometer for the tk locus and then declines for particles of higher LET, including Fe ions. For the hprt locus, the action cross section for mutation is maximal at 95 keV/micrometer but is relatively constant across the range from 61 keV/micrometer to 190 keV/micrometer. The yields of hprt-deficient mutants obtained after HZE exposure to TK6 lymphoblasts may be compared directly with published data on the induction of hprt-deficient mutants in human neonatal fibroblasts exposed to similar ions. The action cross section for induction of hprt-deficient mutants by energetic Fe ions is more than 10-fold lower for lymphoblastoid cells than for fibroblasts. Author (revised by Herner)

A94-62515

RADIATION RISK OF THE CREW MEMBERS OF THE EXPEDITIONS ON THE 'MIR' STATION DURING THE 22ND SOLAR ACTIVITY CYCLE

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The radiation risk at the end of the flight was calculated for the members of the main expeditions on the 'Mir' station. It was based on the absorbed dose dynamics data measured by the board dosimeter. The radiation damage models created for standards of the radiation safety of the space flights were used in the calculations. The analysis of the obtained values of the risk and its dynamics for some cosmonauts are presented in the topic. The risk values delta P are close to the limited levels given by equation of delta P = 0.6 times 10 times T(exp -4), where T- is flight duration in months. Author (revised by Herner)

A94-62516

ANATOMICAL MODELS FOR SPACE RADIATION APPLICATIONS: AN OVERVIEW

W. ATWELL Rockwell International, Houston, TX, U.S.A. vol. 14, no. 10 October 1994 p. 415-422 Life Sciences and Space Research 25 (2) Radiation Biology: Topical Meeting of the COSPAR Interdisciplinary Scientific Commission F of the COSPAR 29th Plenary Meeting, Washington, DC, Aug. 28-Sep. 5, 1992
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Extremely detailed computerized anatomical male (CAM) and female (CAF) models that have been developed for use in space radiation analyses are discussed and reviewed. Recognizing that the level of detail may currently be inadequate for certain radiological applications, one of the purposes of this paper is to elicit specific model improvements or requirements from the scientific user-community. Methods and rationale are presented which describe the approach used in the Space Shuttle program to extrapolate dosimetry measurements (skin doses) to realistic astronaut body organ doses. Several mission scenarios are presented which demonstrate the utility of the anatomical models for obtaining specific body organ exposure estimates and can be used for establishing cancer morbidity and mortality risk assessments. These exposure estimates are based on the trapped Van Allen belt and galactic cosmic radiation environment models and data from the major historical solar particle events. Author (Herner)

A94-62517

REALISTIC COMPUTERIZED HUMAN PHANTOMS

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To estimate the risk resulting from exposures to ionizing radiation, the organ and tissue doses should be assessed. A convenient method is the calculation of these doses using representations of the human body, called models or phantoms, together with computer codes simulating the transport of radiation in the body. Most commonly used are mathematical phantoms whose external and internal volumes are defined by simple geometric bodies. More recently, phantoms constructed from computed tomographic data of real persons were introduced as an improvement. These phantoms present advantages concerning the location and shape of the organs, in particular the hard bone and bone marrow, whose distribution can be assessed with high resolution. So far, three of these phantoms were constructed at the GSF, a fourth is under process. The construction technique is described, and some calculational results of organ doses due to external photon irradiation are presented. Author (Herner)

A94-62518

MODELS OF CNS RADIATION DAMAGE DURING SPACE FLIGHT

J. W. HOPEWELL Univ. of Oxford, Oxford, U.K. vol. 14, no. 10 October 1994 p. 433-442 Life Sciences and Space Research 25 (2) Radiation Biology: Topical Meeting of the COSPAR Interdisciplinary Scientific Commission F of the COSPAR 29th Plenary Meeting, Washington, DC, Aug. 28-Sep. 5, 1992
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The primary structural and functional arrangement of the different cell types within the Central Nervous System (CNS) are reviewed. This was undertaken with a view to providing a better understanding of the complex interrelationships that may contribute to the pathogenesis of lesions in this tissue after exposure to ionizing radiation. The spectrum of possible CNS radiation-induced syndromes are discussed although not all have an immediate relevance to exposure during space flight. The specific characteristics of the lesions observed would appear to be dose related. Very high doses may produce an acute CNS syndrome that can cause death. Of the delayed lesions, selective coagulation necrosis of white matter and a later appearing vascular microangiopathy, have been reported in patients after cancer therapy doses. Lower doses, perhaps very low doses, may produce a delayed generalised CNS atrophy; this effect and the probability of the induction of CNS tumors could potentially have the greatest significance for space flight. Author (revised by Herner)

A94-62526* National Aeronautics and Space Administration, Washington, DC.

HELIUM-ION-INDUCED HUMAN CATARACTOGENESIS

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(Contract W-18-002; DE-AC03-76-SF00098)
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Retrospective and ongoing analyses of clinical records from 347 primary intraocular melanoman patients treated with helium ions at Lawrence Berkeley Laboratory (LBL) will allow examination of the exposure-response data for human cataract; which is a complication of the therapy from incidental exposure of the lens. Direct particle beam traversal of at least a portion of the lens usually is unavoidable in treatment of posterior intraocular tumors. The precise treatment planned for each patient permits quantitative assessment of the lenticular dose and its radiation quality. We are reporting our preliminary results on the development of helium-ion-induced lens opacifications and cataracts in 54 of these patients who had 10% or less of their lens in the treatment field. We believe these studies will be relevant to estimating the human risk for cataract in space flight. Author (revised by Herner)

A94-62530

HAEMOPOIETIC CELL RENEWAL IN RADIATION FIELDS

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Space flight activities are inevitably associated with a chronic exposure of astronauts to a complex mixture of ionizing radiation. Although no acute radiation consequences are to be expected as a rule, the possibility of Solar Particle Events (SPE) associated with relatively high doses of radiation (1 or more Gray) cannot be excluded. It is the responsibility of physicians in charge of the health of astronauts to evaluate before, during and after space flight activities the functional status of hemopoietic cell renewal. Chronic low level exposure of dogs indicate that daily gamma-exposure doses below about 2 cGy are tolerated for several years as far as blood cell concentrations are concerned. However, the stem cell pool may be severely affected. The maintenance of sufficient blood cell counts is possible only through increased cell production to compensate for the radiation inflicted excess cell loss. This behavior of hemopoietic cell renewal during chronic low level exposure can be simulated by bioengineering models of granulocytopoiesis. It is possible to define a 'turbulence region' for cell loss rates, below which an prolonged adaptation to increased radiation fields can be expected to be tolerated. On the basis of these experimental results, it is recommended to develop new biological indicators to monitor hemopoietic cell renewal at the level of the stem cell pool using blood stem cells in addition to the determination of cytokine concentrations in the serum (and other novel approaches). To prepare for unexpected hemopoietic effects during prolonged space missions, research should be increased to modify the radiation sensitivity of hemopoietic stem cells (for instance by the application of certain regulatory molecules). In addition, a 'blood stem cell bank' might be established for the autologous storage of stem cells and for use in space activities keeping them in a radiation protected container. Author (revised by Herner)

A94-62545* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

ESTIMATES OF HZE PARTICLE CONTRIBUTIONS TO SPE RADIATION EXPOSURES ON INTERPLANETARY MISSIONS

L. W. TOWNSEND NASA, Langley Research Center, Hampton, VA, US, F. A. CUCINOTTA NASA, Langley Research Center, Hampton, VA, US, J. W. WILSON NASA, Langley Research Center, Hampton, VA, US, and R. BAGGA Old Dominion Univ., Norfolk, VA, US vol. 14, no. 10 October 1994 p. 671-674 Life Sciences and Space Research 25 (2) Radiation Biology: Topical Meeting of the COSPAR Interdisciplinary Scientific Commission F of the COSPAR 29th Plenary Meeting, Washington, DC, Aug. 28-Sep. 5, 1992
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Estimates of radiation doses resulting from possible HZE (high energy heavy ion) components of Solar Particle Events (SPEs) are presented for crews of manned interplanetary missions. The calculations assume a model spectrum obtained by folding measured solar flare HZE particle abundances with the measured energy spectra of SPE alpha particles. These hypothetical spectra are then transported through aluminum spacecraft shielding. The results, presented as estimates of absorbed dose and dose equivalent, indicate that HZE

components by themselves are not a major concern for crew protection but should be included in any overall risk assessment. The predictions are found to be sensitive to the assumed spectral hardness parameters.
Author (Herner)

A94-62571* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

GALACTIC COSMIC RAY RADIATION LEVELS IN SPACECRAFT ON INTERPLANETARY MISSIONS

J. L. SHINN NASA. Langley Research Center, Hampton, VA, USA, J. E. NEALY NASA. Langley Research Center, Hampton, VA, USA, L. W. TOWNSEND NASA. Langley Research Center, Hampton, VA, USA, J. W. WILSON NASA. Langley Research Center, Hampton, VA, USA, and J.S. WOOD Flight Mechanics and Control Inc., Hampton, VA, USA vol. 14, no. 10 October 1994 p. 863-871 Life Sciences and Space Research 25 (2) Radiation Biology: Topical Meeting of the COSPAR Interdisciplinary Scientific Commission F of the COSPAR 29th Plenary Meeting, Washington, DC, Aug. 28-Sep. 5, 1992

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Using the Langley Research Center Galactic Cosmic Ray (GCR) transport computer code (HZETRN) and the Computerized Anatomical Man (CAM) model, crew radiation levels inside manned spacecraft on interplanetary missions are estimated. These radiation-level estimates include particle fluxes, LET (Linear Energy Transfer) spectra, absorbed dose, and dose equivalent within various organs of interest in GCR protection studies. Changes in these radiation levels resulting from the use of various different types of shield materials are presented.
Author (Herner)

A94-62572

FLUXES OF GALACTIC IRON NUCLEI AND ASSOCIATED HZE SECONDARIES, AND RESULTING RADIATION DOSES, IN THE BRAIN OF AN ASTRONAUT

P. A. CRAVEN Cranfield Institute of Technology, Bedfordshire, UK and M. J. RYCROFT Cranfield Institute of Technology, Bedfordshire, UK vol. 14, no. 10 October 1994 p. 873-878 Life Sciences and Space Research 25 (2) Radiation Biology: Topical Meeting of the COSPAR Interdisciplinary Scientific Commission F of the COSPAR 29th Plenary Meeting, Washington, DC, Aug. 28-Sep. 5, 1992

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Although galactic iron nuclei constitute only a small percentage of the total flux of radiation in space, they are extremely significant from a biological standpoint, and represent a concern for long term manned space missions of the future. Dosages resulting from iron nuclei, and the high-charge secondary nuclei subsequently produced in nuclear fragmentation reactions, have been calculated at the center of a simple model of the human brain, shielded by various thicknesses of aluminum. Three mission scenarios are considered representing different geomagnetic shielding conditions at solar minimum. Without artificial shielding absorbed dose rates outside the magnetosphere, polar orbit and in the proposed Space Station orbit, are approximately 0.3, 0.1 and 0.03 cGy/year respectively, corresponding to dose equivalent rates of 8.0, 2.5 and 0.8 cSv/year, and decreasing by roughly a factor of two behind 10 g/cm sq of aluminum. In line with new approaches to risk estimation based on particle fluence and track structure, calculations of the number of cell nuclei likely to be struck by these HZE particles are also presented. Behind 10 g/cm sq of aluminum, 3.4%, 1.3% and 0.5% of cell nuclei at the center of the brain will be traversed at least once by such a particle within three years, for the three mission scenarios respectively.
Author (revised by Herner)

A94-62573

RADIATION PROTECTION ISSUES IN GALACTIC COSMIC RAY ASSESSMENT

W. K. SINCLAIR National Council on Radiation and Measurements, Bethesda, MD, USA vol. 14, no. 10 October 1994 p. 879-884 Life Sciences and Space Research 25 (2) Radiation Biology: Topical Meeting of the COSPAR Interdisciplinary Scientific Commission F of the COSPAR 29th Plenary Meeting, Washington, DC, Aug. 28-Sep. 5, 1992

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Radiation protection involves the limitation of exposure to below threshhold doses for direct (or deterministic) effects and a knowledge of the risk of stochastic effects after low doses. The principal stochastic risk associated with low dose rate galactic cosmic rays is the increased risk of cancer. Estimates of this risk depend on two factors (a) estimates of cancer risk for low Linear Energy Transfer (LET) radiation and (b) values of the appropriate radiation weighting factors, W(subR), for the high-LET radiations of galactic cosmic rays. Both factors are subject to considerable uncertainty. The low-LET cancer risk derived from the late effects of the atomic bombs is vulnerable to a number of uncertainties including especially that from projection in time, and from extrapolation from high to low dose rate. Nevertheless, recent low dose studies of workers and others tend to confirm these estimates. W(subR), relies on biological effects studied mainly in non-human systems. Additional laboratory studies could reduce the uncertainties in W(subR) and thus produce a more confident estimate of the overall risk of galactic cosmic rays.
Author (revised by Herner)

A94-62574 National Aeronautics and Space Administration, Washington, DC.

SINGLE-TRACK EFFECTS AND NEW DIRECTIONS IN GCR RISK ASSESSMENT

S. B. CURTIS University of California, Berkeley, CA, USA vol. 14, no. 10 October 1994 p. 885-894 Life Sciences and Space Research 25 (2) Radiation Biology: Topical Meeting of the COSPAR Interdisciplinary Scientific Commission F of the COSPAR 29th Plenary Meeting, Washington, DC, Aug. 28-Sep. 5, 1992

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Light flashes in the eye as recorded by astronauts on missions outside the geomagnetosphere are presumably caused by single particle traversals of galactic cosmic rays traversing the retina. Although these flashes are not considered to have deleterious short- or long-term effects on vision, they are testimony that the body can detect single particle traversals. The frequencies of the flashes implicate ions in the charge range of 6 to 8 (ie., carbon and/or oxygen ions). Other particles with higher charge and causing more ionization are present at lower frequencies. The possibility of the importance of such single-track effects in radiation carcinogenesis and other late effects suggest that a risk assessment system based on particle fluence rather than absorbed dose might be useful for assessing risk on long-term space missions. Such a system based on the concept of risk cross section is described. Human cancer risk cross sections obtained from recently compiled A-bomb survival data are presented, and problems involving the determination of the Linear Energy Transfer (LET)-dependence of such cross sections are discussed.
Author (revised by Herner)

A94-62583

ISSUES AND PROBLEMS FOR RADIOBIOLOGICAL RESEARCH IN SPACE

J. KIEFER Strahlenzentrum der Justus-Liebig-Universitat, Giessen, Germany vol. 14, no. 10 October 1994 p. 979-988 Life Sciences and Space Research 25 (2) Radiation Biology: Topical Meeting of the COSPAR Interdisciplinary Scientific Commission F of the COSPAR 29th Plenary Meeting, Washington, DC, Aug. 28-Sep. 5, 1992

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The uniqueness of the space radiation field creates specific problems in the evaluation of hazards to men and materials. Comprehensive measurements of all physical parameters are necessary but not sufficient. Particular attention has to be paid to variables like solar flares by applying fast-responding active dosimetry. The assessment of biological consequences poses even more problems. There are no human data for the kinds of particles seen in space and they will presumably never be available. The only reasonable approach is therefore to use the information obtained for the other radiations and check their applicability for the space situation. This involves both the study of fundamental processes in ground experiments as well as their verification in space missions. Special emphasis has to be laid on the modification of radiation effects by flight-dynamic factors and microgravity. Radiation protection guidelines for space flights cannot simply be transformed from existent regulations designed for radiation workers on earth but have to be tailored to the specific situation in space. Author (Hemer)

A94-62584* National Aeronautics and Space Administration, Washington, DC.

IMPORTANCE OF DOSE-RATE AND CELL PROLIFERATION IN THE EVALUATION OF BIOLOGICAL EXPERIMENTAL RESULTS

S. B. CURTIS Univ. of California, Berkeley, CA, U.S.A. vol. 14, no. 10 October 1994 p. 989-996 Life Sciences and Space Research 25 (2) Radiation Biology: Topical Meeting of the COSPAR Interdisciplinary Scientific Commission F of the COSPAR 29th Plenary Meeting, Washington, DC, Aug. 28-Sep. 5, 1992
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The nuclei of cells within the bodies of astronauts traveling on extended missions outside the geomagnetosphere will experience single traversals of particles with high Linear Energy Transfer (LET) (e.g., one iron ion per one hundred years, on average) superimposed on a background of tracks with low LET (approximately one proton every two to three days, and one helium ion per month). In addition, some cell populations within the body will be proliferating, thus possibly providing increasing numbers of cells with 'initiated' targets for subsequent radiation hits. These temporal characteristics are not generally reproduced in laboratory experimental protocols. Implications of the differences in the temporal patterns of radiation delivery between conventionally designed radiation biology experiments and the pattern to be experienced in space are examined and the importance of dose-rate and cell proliferation are pointed out in the context of radiation risk assessment on long mission in space. Author (revised by Hemer)

A94-62586* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.

CELLULAR CHANGES IN MICROGRAVITY AND THE DESIGN OF SPACE RADIATION EXPERIMENTS

D. R. MORRISON NASA. Johnson Space Center, Houston, TX, USA vol. 14, no. 10 October 1994 p. 1005-1019 Life Sciences and Space Research 25 (2) Radiation Biology: Topical Meeting of the COSPAR Interdisciplinary Scientific Commission F of the COSPAR 29th Plenary Meeting, Washington, DC, Aug. 28-Sep. 5, 1992
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Cell metabolism, secretion and cell-cell interactions can be altered during space flight. Early radiobiology experiments have demonstrated synergistic effects of radiation and microgravity as indicated by increased mutagenesis, increased chromosome aberrations, inhibited development, and retarded growth. Microgravity-induced changes in immune cell functions include reduced blastogenesis and cell-mediated, delayed-type hypersensitivity responses, increased cytokine secretions, but inhibited cytotoxic effects an macrophage differentiation. These effects are important because of the high radiosensitivity of immune cells. It is difficult to compare ground studies with space radiation biology experiments because of the complexity of the space radiation environment, types of radiation damage and repair mechanisms. Altered intracellular functions and molecular mechanisms must be considered in the design and interpretation of space radiation experiments. Critical steps in radiocarcinogenesis could be affected. New cell systems and hardware are needed to determine the biological effectiveness of the low dose rate, isotropic, multispectral space radiation and the potential usefulness of radioprotectants during space flight. Author (Hemer)

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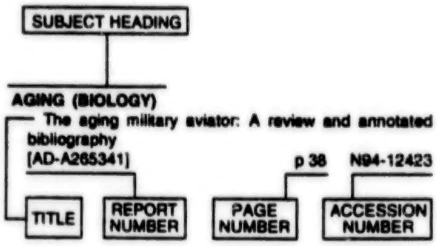
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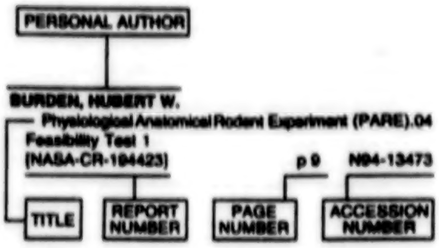

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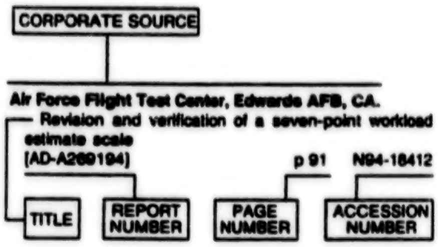
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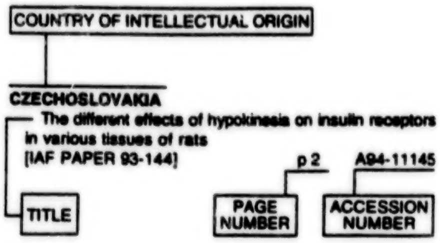
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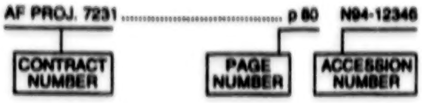
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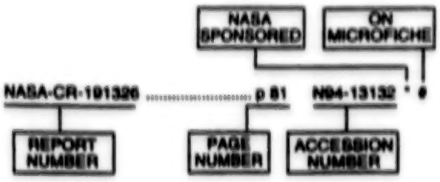

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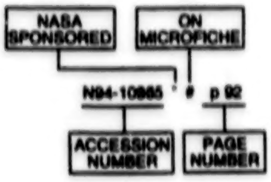

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4. Title and Subtitle Aerospace Medicine and Biology A Continuing Bibliography (Supplement 395)		5. Report Date December 1994
		6. Performing Organization Code JTT
7. Author(s)		8. Performing Organization Report No.
		10. Work Unit No.
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